URANUS METEO SENSOR

PRODUCT MANUAL

Version *1.5*
20-Jul-2023

VERSION HISTORY

Version #	**Implemented By**	**Revision Date**	**Reason**
1.0	*Evans Souglakos*	*25/06/2022*	*Initial Document*
1.1	*Evans Souglakos*	01/10/2022	Add Mechanical Drawings. Add Emissivity for IR Sensor. Modify Buttons Operation.
1.2	*Evans Souglakos*	10/10/2022	Syntax errors
1.3	*Evans Souglakos*	10/11/2022	Fixes in GPS 6P4C output Fix typos in UNC threads, review warning notes in the document
1.4	*Evans Souglakos*	29/11/2022	Add information about transmitting sensor readouts to the GPS port
1.5	*Evans Souglakos*	20/07/2023	Explanation on cloud sensing. Syntax fixes.

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INTRODUCTION

1.1 PURPOSE

Thank you for purchasing the Uranus Meteo Sensor. This pocket-sized device is an all-around astronomer, and astro-imager companion. Smaller than the size of a cigarette box, and equipped with a variety of digital sensors, can precisely report the ambient temperature, humidity, pressure, cloud height, cloud coverage, astronomical dawn, twilight time, and the night sky brightness.

1.2 IN THE BOX

The box contains the Uranus Meteo Sensor along with a silicon protective case. The case is already fitted on the Uranus Meteo Sensor In the box, you will also find a USB type C cable which is required for battery charging and data exchange between the device and your computer.

1.3 DEVICE CARE

The device electronics are housed inside an aluminum anodized blue enclosure. The enclosure is made from aircraft aluminium alloy type 6061 which provides very good corrosion resistance. The label button on top of the device is water-resistant and the material was selected to last a long time.

The device is **not waterproof** and it should not be installed outside for long term, exposed to weather conditions e.g., direct sunlight, rain, snow. However, the device can be placed into a roll-off observatory to measure night conditions, for astronomical observations, when the roof is open.

A black silicone case protects the device from drops and scratches. Also, it does not allow contact with the aluminium enclosure with your palm. (during cold nights the heat transfer from your hand to the metal can be disturbing)

We strongly suggest keeping this case, especially if you plan to use the device as a mobile unit (have it in your pocket etc). In case you need to place the device inside your observatory, you can remove the silicon case and use the screws at the bottom of the device to securely attach Uranus on a plate (2xM3 screws) or a tripod ball head (1/4-20 UNC thread).

DEVICE DESCRIPTION

1.4 DESIGN OVERVIEW

1.5 BATTERY OPERATION

The device includes a rechargeable 3.6Volts - 3xAAA NiMH battery back. The current capacity of the battery pack is 600mA. The battery can be recharged from the USB-C socket. A battery management controller inside the device ensures that the device is properly charged following the NiMH battery charging characteristics. When the battery is fully charged, the controller cuts the charging current. Battery levels are shown on the OLED display.

Typically, NiMH batteries can be recharged hundreds of times However, battery life is limited to up to 5 years. After that, it can be easily replaced with a new rechargeable battery pack. To do that:

1. Remove the two screws from the back of the device and lift the bottom enclosure plate.
2. Locate the battery and disconnect the two wires.
3. Remove and replace the battery pack. Pay attention to the battery + and – cables. (black is -, red is +).

There is a printed indication close to the device socket showing how to attach the cables with the correct polarity. Please note that the device has reverse polarity protection so if you accidentally reverse the battery polarity, the device will just not start. (It will not get harmed).

1.6 BATTERY CHARGING

When the USB-C cable is inserted into the device, the battery automatically enters a charging cycle. The internal NiMH change controller decides if the battery requires charging and starts the charge sequence. Also, it stops the sequence when the battery is fully charged.
During the charging sequence, the battery pack produces some heat (a normal condition during any battery charging). Although all temperature sensors are placed into a different compartment of the aluminum enclosure (to isolate any heat emission from the electronic board) this will affect them and offset their temperature readout by 2-3 °C. When the charging cycle ends, the battery is cooled down and the temperature sensors readout return to normal values.

To re-initiate a battery charge sequence, the USB cable should be re-inserted and the battery should be lower than 90% of its capacity.

This ensures that during remote operation of the device the battery will not produce heat so it won't enter, periodically, into battery charging cycles. Therefore, the sensors will not be affected by any abnormal temperature fluctuation.

If you intend to permanently mount the device on your observatory, you can open the back of the device (remove the two screws and lift the back plate) and easily remove the whole battery or just disconnect one battery clip.

1.7 USB OPERATION

The device has a USB-C socket on its right side that charges the internal battery pack, and most important, exchange information with your PC. The USB communication is USB 2.0. Maximum cable length that ensures stable communication between Uranus and your PC is up to 5 meters / 15 feet.

The device prefers the USB power channel (+5V) so when the USB cable is inserted, the device instantly switches to USB power and battery power consumption falls to zero. When you remove the USB, the device instantly switches back to battery power consumption, and operation (no disruption in device operation happens).

1.8 POWER CONSUMPTION AND SLEEP MODE

Uranus consumes 60mA during its normal battery operation. When the device is on battery “mobile” mode (USB cable is not plugged) device enters into sleep mode after 5 minutes of inactivity (default sleep interval – can be changed from Unity software). Sleep mode is practically, to the user experience, a full shutdown of the device.

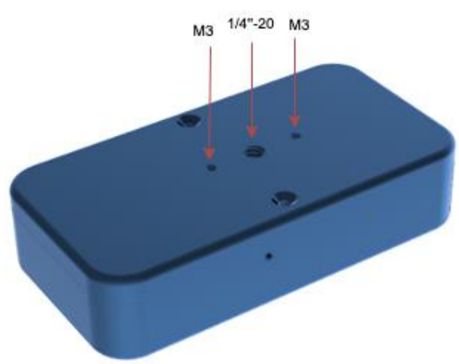
In sleep mode, the device consumes up to 15µA. This ultra-low power consumption allows the battery to last for more than a year! The right push-button single click brings the device back to life, normal operation. Due to this power save feature, the device does not need a classic switch button to turn on or off.

1.9 DEVICE RESET

A pinhole on the left side of the enclosure fully resets the microcontroller of the device. If your Uranus does not turn on for any reason, carefully insert a small needle and press this button once.

1.10 MOUNTING HOLES

Uranus has two different types of mounting holes at the back of its enclosure.
A couple of M3 holes and a 1/4-20 UNC are available according to the image below.



The device can be attracted in two different ways:

- On a small tripod using the 1/4-20 UNC hole, pointing to the zenith of the sky.
- “Piggyback” on your telescope OTA: In this case, please ensure that the sensor front area is as close to the front of your telescope. This ensures that each optical sensor‘s field of view is not obstructed by an object (such as the telescope tube itself).

SENSORS

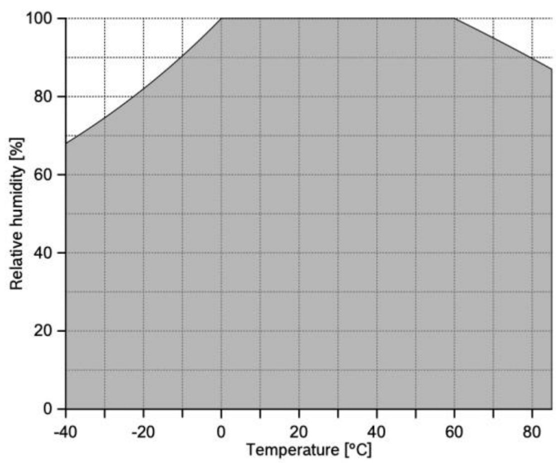
1.11 AMBIENT TEMPERATURE

A digital sensor measures temperature ranges from -40°C to +60 °C. Temperature readings are taken every 10 seconds, to prevent any heat that might build up if there were short time interval readings. After every readout, the sensor enters into sleep mode in which power consumption is at a minimum. All the above ensure that the sensor measures precisely the current ambient temperature. Temperature sensor value is also used for temperature compensation of the pressure and humidity sensors.

1.12 RELATIVE HUMIDITY

A digital relative humidity sensor ensures accuracy tolerance of ±3 % relative humidity. The humidity sensor provides a fast response time and high overall accuracy over a wide temperature range. The integrated temperature sensor has been optimized for the lowest noise and highest resolution. As the temperature sensor, each reading is taken every 15 seconds to minimize internal sensor heat-up and reduce power consumption.

The image below shows the humidity sensor operating range



The dew point is the temperature the air needs to be cooled to (at constant pressure) to achieve a relative humidity (RH) of 100%. At this point, the air cannot hold more water in the gas form. Dew Point is automatically calculated by a math formula that uses readings from temperature and relative humidity sensors.

1.13 BAROMETRIC PRESSURE

The pressure sensor is an absolute barometric pressure sensor with extremely high accuracy, resolution and low noise. The sensor provides full accuracy from 300 to 1100 hPa. Each reading is taken every 10 seconds to minimize internal sensor heat-up and reduce power consumption.

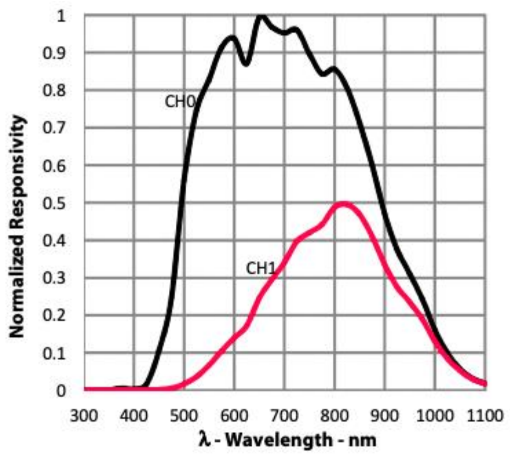
Uranus firmware can calculate and display relative barometric (sea level) pressure and barometric altitude. *Sea level required GPS lock to use the real reported altitude and make the calculation.*

1.14 LIGHT / SKY BRIGHTNESS

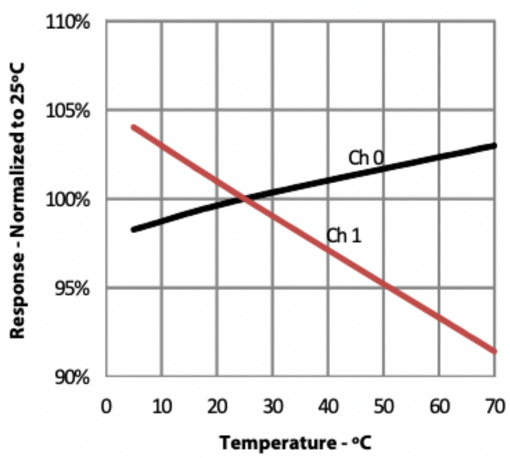
The light sensor has a very-high sensitivity light-to-digital converter that transforms light intensity into a digital signal output. The sensor combines one broadband photodiode (visible plus infrared) and one infrared-responding photodiode on a single CMOS integrated circuit. By subtracting infrared from broadband light, the sensor can precisely calculate visible light. This is the reason why it does not require an IR-Cut glass. Moreover, the sensor comes in a UV-rejection package.

The light sensor has a very high dynamic range of 600M:1 able to measure from direct sunlight to very dark skies (practically up to 22.0 mag/arcsec^2). Its highest sensitivity is close to 188 μlux.

The light sensor provides data to the microcontroller of Uranus where illuminance (ambient light level) in lux is derived using an empirical formula to approximate the human eye response. Lux readings are converted to Magnitudes per square arcsecond, abbreviated as MPSAS. In addition, Uranus calculates the NELM (Naked Eye Limit Magnitude) and Bortle Scale.



Spectral Responsivity: Two-channel response allows for tuneable illuminance (lux) calculation regardless of the transmissivity of glass.



White LED Response vs Temp: Effect of temperature on the device response for a broadband white light source. A temperature compensation algorithm is automatically applied after every readout.

Each light sensor is factory calibrated with a precision close to ±5%. However, if Uranus is going to be placed inside a 3rd party enclosure, the light sensor will require an offset adjustment which can be configured via our supplied software.

The light sensor has a 25° FOV opening, covering range, which is appropriate to take an average measurement of a whole asterism. (Please note that the purpose of this sensor is not to measure a narrow part of the deep sky).

The firmware of the Uranus device works in combination with the light sensor and automatically:

- Compensates the dark current of the sensor based on ambient temperature from the final reading.
- Configures sensor analog gain and integration time to adapt to the current light conditions and utilize the full dynamic range of the sensor.

An average reading (10 consecutive measurements) of the light sensor can be taken by keeping pressed the “Measure” push button or instructed from USB communication (on-demand).

1.15 CLOUD INFRARED SENSOR

A high-precision non-contact infrared temperature sensor of 60° FOV is used to measure the sky temperature. By consulting ambient temperature, the firmware uses a formula to determine the existence of clouds.

The difference between the ambient temperature and the sky temperature is lower when there is a clear sky compared with a cloudy sky. A sky temperature correction model is applied to account for excessive atmospheric long-wave radiation during summer at different locations. A clear view of the sky is important because any terrestrial object can cause parasite IR radiation.

Sensor IR temperature measurements and cloud index calculations based on the temperature correction model are taken every 250 msec.

GPS RECIEVER

Uranus incorporates an ultra-low consumption and fast-position GPS receiver. The receiver has 66 acquisition channels, and 22 tracking channels and can calculate, and predict orbits automatically using the ephemeris data (up to 3 days) stored in internal RAM, so can fix position quickly even at indoor signal levels with low power consumption. A cold GPS start takes about 30 seconds under open sky view (can take longer than 1-3 minutes if obstacles are blocking the sky around the receiver). As the Uranus device enters into sleep mode but never shuts down, the GPS module battery keeps the receiver in “warm” start mode. A warm start (lock satellites and display precise time and coordinates) happens in less than 5 seconds.

If some or all the GPS data is missing or out-of-date, the GPS receiver needs to get updated information from the satellites before it can accurately fix a current position. The types of data that are out-of-date or missing determine how long the GPS receiver takes to initialize. If the Uranus is, several hundred miles away from where it was last used or has been stored for a prolonged time, initialization will take longer.

Uranus communicates with the internal GPS receiver and displays information about:

- Latitude and Longitude of your location
- Satellite Lock Count
- Local Date and Time (based on your defined time zone)
- Ground Speed
- Bearing in Degrees
- Moon Age and Visibility
- Astronomical Dawn and Dusk Time

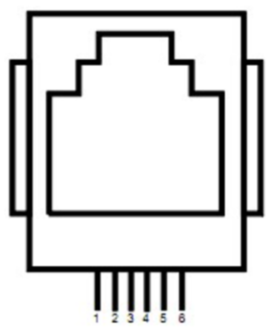
GPS receiver updates from Uranus processor for new GPS data every second (1Hz). (This can change to higher update rates (up to 10Hz) – will be supported in future firmware releases)

Uranus device has a 6P4C port that can (when enabled from supplied software) output NMEA GPS lines. This port can be used to provide GPS data to other devices such as telescope mounts that accept NMEA messages.

Uranus can be powered directly by PIN3. Some mounts like 10Micron deliver 5Volts in this specific PIN and can power on the Uranus Device and also charge the battery. (No need to plug in a USB cable)

6P4C GPS NMEA Output Pinout

PIN 1	N/C
PIN 2	RX
PIN 3	VCC (5V INPUT)
PIN 4	GND
PIN 5	TX
PIN 6	N/C



In addition, firmware v $\geq$ 1.3 also **transmits:**

- **ambient temperature**
- **absolute pressure**

readouts by using NEMA 1083 protocol. If you own a 10Micron mount you can utilize these data and let your equatorial mount perform refraction corrections.

For the 10Micron mount connectivity, a special RJ9 to RJ11 cable is required. This optional cable can be purchased with this SKU: ***PEG-URANUS-10MCORD***

MEMORY BANKS

The device includes a FRAM memory, capable to store up to 500 records of sensor data. “Store” (left) push-button press for 2 seconds stores the below data into the next available memory bank number:

- Date & Time (GPS)
- Latitude
- Longitude
- Ambient temperature
- Humidity
- Altitude
- Pressure (absolute)
- Light (MPSAS)
- Cloud Index (%)

Memory banks can be read or fully wiped from (Unity Platform) software. The technology of this RAM (FRAM) ensures that memory can last for multiple billions of write or erase cycles.

DEVICE OPERATION

1.16 FIRST-TIME USE

An important step during the first-time use of the device is to initialize the GPS receiver with the visible satellites of your area.

Locate an open space with an unobstructed view of the sky and place Uranus (with the top label looking up) in a stand-still position for about a minute.

This ensures that the GPS receiver will quickly discover available satellites. GPS sequence first displays (stratum 0) date & time data. After that, it needs to fix position (latitude and longitude coordinates) via 4 satellites (at minimum).

It can take anywhere from 30 seconds to 3 minutes for the GPS receiver to gather enough satellite data to get a position fix for the first time. This is required only during **first usage (GPS cold start).** After that, GPS will be fully operational in the same location after 5-6 seconds. (warm start under the open sky).

If some or all the data is missing or out-of-date, the GPS receiver needs to get updated information from the satellites before it can accurately fix a current position. The types of data that are out-of-date or missing determine how long the GPS receiver takes to initialize. If the Uranus is several hundred miles away from where it was last used or has been stored for a prolonged time, initialization will take longer.

Please note that internal battery replacement requires a GPS cold start initialization process

Uranus battery is fully charged, straight out of the factory. However, we recommend plugging the USB cable and re-charge the battery. (If the device is left for a long time on the shelf the battery levels will be lower than expected) A full charge time may take 2.5 hours when the battery is at very low power levels.

During initial usage (out of the box), one hour of charging time should be sufficient. Please note that the internal charging circuit automatically **cuts the battery charging sequence when the battery comes to a fully charged level so no need to worry about when to unplug the USB cable**).

1.17 MOBILE USAGE

Press the right **[>>]** button once, to bring Uranus, from sleep mode, back to normal operation. The device instantly boots and the Pegasus Logo is visible on the OLED display for about a second. **After that, the device is fully operational**. GPS is also operational with satellite data in about 5-6 seconds (GPS warm start).

Please note that if more than 3 days have passed since the last GPS operation, the GPS receiver might take longer (up to 30 seconds) to locate and track ephemeris data of available satellites.

Press **[>>]** button to move forward or press **[<<]** button to move backward to all available display pages of the device

[For detailed information please read the "*On Screen Display Menus"* section of this document]

Keep pressing **[>>] (Measure)** button for **2 seconds** to trigger a Sky Quality measurement. Remember to point the device toward the area of the sky you would like to acquire a light measurement.

Keep pressing **[>>] (Measure)** button for **5 seconds** to turn off the display. The device will still enter in sleep mode after the configured time. Press any button to turn it on again

Keep pressing **[<<] (Store)** button for **2 seconds** to store all retrieved sensor data into the device's next available memory bank.

(By the time you press the store button a sky quality measurement is automatically taken and included into the memory bank).

1.18 REMOTE USAGE

If you are going to install the device into your observatory, just plug the USB cable and let Uranus run with the USB cable attached. The battery will be fully charged once but will never provide power to the device.

The device automatically selects the USB power source and drops to zero the battery power consumption. As soon as the USB cable is plugged in, sleep mode is disabled. This ensures that Uranus is always up and running during USB operation.

When Uranus exchanges information with the PC, the OLED display is automatically turned off. This ensures that light from the screen:

1) will not affect astronomical observations inside a roll-off observatory or any other facility.
2) will not affect the Sky Quality measurement.

ON SCREEN DISPLAY

1.19 ORGANIC LED

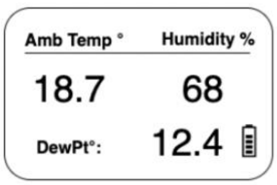
Uranus device has a 128x64 pixel, 1.2-inch diagonal organic led display (OLED) on top. This technology provides high contrast, wide viewing angles, and operation under low temperatures without frame rate slow-down impact. (an effect that happens on classic LCD displays). A protective transparent red film on top of the display ensures that your night vision will be unaffected.

[Please note that device has been designed with the night astronomer in mind. Therefore, this OLED display is not easily visible in direct sunlight. Brightness cannot be increased at levels that will allow that.]

1.20 MENUS

[Please note that the below examples are displayed in metric units. Imperial units can be set from supplied (Unity) software. After that, Uranus will display on the OLED screen all units in imperial format.]

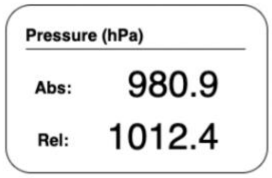
Page 1



- **Ambient Temperature**: The current measured temperature of your surroundings.
- **Humidity (Relative)** refers to the moisture content (i.e., water vapor) of the atmosphere, expressed as a percentage of the amount of moisture that can be retained by the atmosphere (moisture-holding capacity) at a given temperature and pressure without condensation.
- **Dew Point** is the temperature the air needs to be cooled to (at constant pressure) to achieve a relative humidity (RH) of 100%. At this point, the air cannot hold more water in the gas form.
- **Battery Level** displays the battery's available power. When USB is inserted, the device enters charging mode and the last battery icon (from the image below) appears on the screen.

2%, 10%, 25%, 50%, 75%, 100%, on USB power or charging mode.

Page 2



- **Station Pressure**: Named also as absolute pressure is the measured atmospheric pressure at the current location.
- **Sea Level Pressure:** Named also as relative pressure is the atmospheric pressure corrected to sea-level conditions. To compare pressure conditions from one location to another, meteorologists correct the measured pressure (referred to as absolute pressure) to sea-level conditions.

* Pressure is reported in hectopascal units (hPa).

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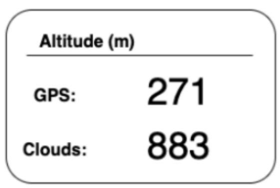

- **Altitude GPS**: This is your precise altitude, reported by the GPS receiver. This (GPS) readout is displaced only if there is a GPS Satellite Lock.
- **Altitude Approx**: If a GPS satellite lock is not available, the device reports barometric (approximate) altitude. It measures altitude by calculating the air pressure of your specific location. The highest the altitude, the lowest the pressure. Of course, this calculation is an approximate calculation of your altitude and can vary +-10 to 50 meters from the actual altitude. The temperature affects the barometric altitude calculation.
- **Altitude Cloud Base**: Cloud Base is the altitude at which the clouds are located. Knowing the temperature and relative humidity we can easily calculate the cloud base. The base of the cloud forms at the altitude at which the rising air cools and condensation starts.

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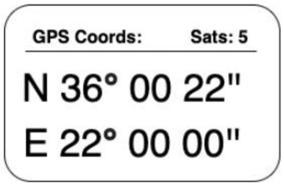

- **Satellite Count**: How many GNSS satellites are locked from the GPS receiver. Four (4) satellites are required at a minimum to fix your 3D position: GPS latitude, longitude, altitude, and time). At any given time, at least 24 active satellites are orbiting over 12,000 miles above the earth. The positions of the satellites are constructed in a way that the sky above your location will always contain at most 12 satellites (usually 8-9).
- **Latitude**: The geographic coordinate that specifies the north–south position of your point on the Earth's surface.
- **Longitude**: The angle from the prime meridian, measured to the east (longitudes to the west are negative)

Latitude and Longitude are displayed in Degrees, Minutes, and Seconds, known as the DMS format.

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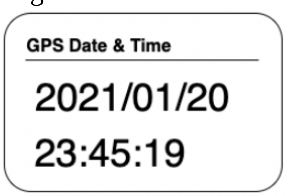

- **Date & Time (Local)**: The device displays the **local** date and time. It takes the super-accurate GPS time (stratum 0) and calculates the local time by offsetting your time zone. *(Your time zone offset can be set from Unity software and is stored in the device's memory).*

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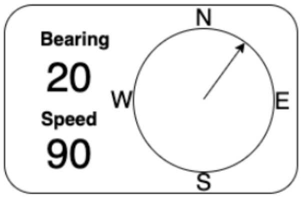

- **Bearing (GPS):** is the compass direction from your current position to your intended destination. It describes the direction of a destination or object. If you're facing due north and want to move toward a building directly behind you, then the bearing would be south. GPS devices calculate bearing based on the target coordinates and the GPS receiver's present location. Next, the GPS determines the exact direction you must travel by measuring your position in approximately one-second intervals. If you are stationary or moving slowly, the direction of travel cannot be calculated, so measurement errors may occur.

> Bearing becomes extremely reliable once you are moving at a consistent speed. If you are on a standstill position, bearing might show variations in directions due to reception in GPS satellite signal. Satellite count lock also affect the reliability of the bearing readout.

- **Speed (GPS):** The GPS receiver calculates your speed using algorithms in the Kalman filter. The receiver computes speed by a combination of movement per unit of time and computing the Doppler shift in the pseudo-range signals from the satellites. The speed output is a smoothed value.

  In a split second, the GPS tracker will generally perform the following tasks to determine speed:

  - Convert the difference between the two latitudinal/longitudinal positions into a unit of measurement
  - Determine the difference between the two timestamps to calculate how long it took to get from Point A to Point B.
  - Calculate the average speed based on these results

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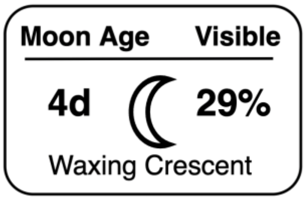

Reports **Moon Age** (how many days have passed after the new moon) and **Visibility** of the moon in a percentage.

Firmware v1.4 and above reports **Moon Rise and Set Time**. *You should have a GPS lock to view this information as this calculation requires local coordinates (latitude and longitude)*.

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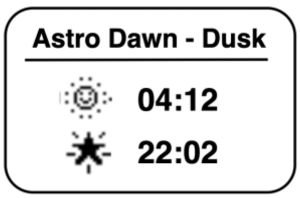


Twilight is defined according to the solar elevation angle, which is the position of the geometric center of the sun relative to the horizon. There are three established and widely accepted *subcategories* of twilight: civil twilight (nearest the horizon), nautical twilight, and astronomical twilight (farthest from the horizon). In our case, we are interested in astronomical twilight (dusk and dawn time) calculation.

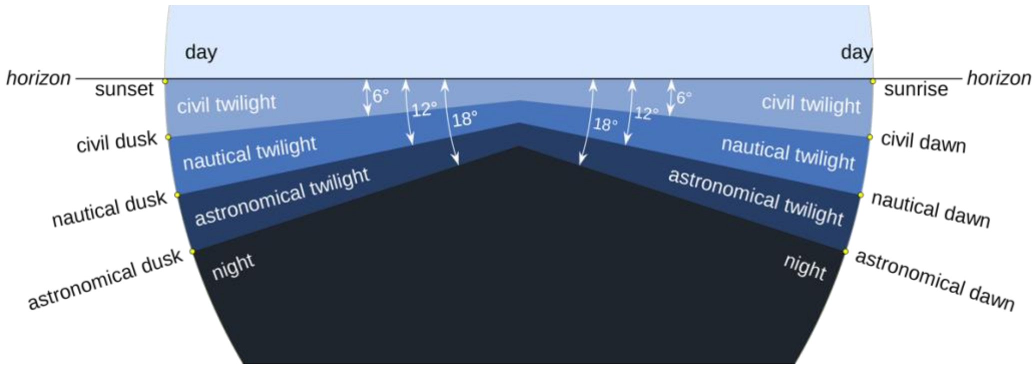
Uranus reports the astronomical dusk and dawn time of your location based on the GPS latitude, longitude, date time, time zone and daylight savings.

Astronomical Dusk is the moment when the geometric center of the Sun is 18 degrees below the horizon in the evening.

Astronomical Dawn is the moment when the geometric center of the Sun is 18 degrees below the horizon in the morning.

After astronomical dusk and before astronomical dawn, the sky is not illuminated by the sun

Dusk and Dawn



Morning astronomical twilight begins (astronomical dawn) when the geometric center of the sun is 18° below the horizon in the morning and ends when the geometric center of the sun is 12° below the horizon in the morning. Evening astronomical twilight begins when the geometric center of the sun is 12° below the horizon in the evening and ends (astronomical dusk) when the geometric center of the sun is 18° below the horizon in the evening.

In some places (away from urban light pollution, moonlight, auroras, and other sources of light), where the sky is dark enough for nearly all astronomical observations, astronomers can easily make observations of point sources such as stars both during and after astronomical twilight in the evening and both before and during astronomical twilight in the morning.

However, some critical observations, like faint items such as nebulae and galaxies, may require observation beyond the limit of astronomical twilight. Theoretically, the faintest stars detectable by the naked eye (those of approximately the sixth magnitude) will become visible in the evening at astronomical dusk, and become invisible at astronomical dawn.

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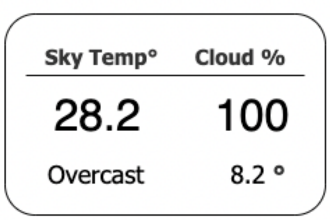


- **Sky Temperature**: This is the temperature measured by the Infrared thermocouple sensor. All bodies above absolute zero emit some radiation. This is "black-body" radiation and it can be correlated to temperature using the Stefan-Boltzmann law. The infrared thermometer uses this to precisely calculate the temperature by measuring this radiation.
- **Cloud Index (%):**
  The difference between the ambient temperature and the sky temperature along with a sky temperature correction model provides the cloud index percentage. This means the % of clouds in your sky. The higher the percentage, the more clouds.
  - A zero percentage indicates a clear sky

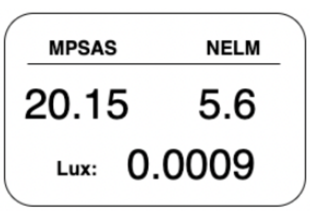
    - A low percentage (10-15%) indicates high-layered clouds
    - A medium percentage (50%) indicates scattered low cloud
    - A 100% indicates an overcast sky.

- **Cloud Type**
  Based on the Cloud Index, the device reports the sky cloud conditions. Five condition types are displayed:
    - Overcast, Cloudy, Spare Clouds, Haze, Clear.
- **Temperature Difference**
  On the bottom right of the display, the difference in degrees between the ambient temperature and the sky temperature is shown.

Sky Quality - On-demand page

How to take a Sky Quality measurement:

1. Raise your hand and point the Uranus device to the area of the sky you would like to take a light measurement.
2. Press **Measure [>>]** button for 2 seconds
3. OLED display instantly shuts off
4. Uranus takes one light measurement
5. If the sensor gain is high enough and it triggers a measurement overflow, the device will automatically adjust the sensor gain to a lower value and retake the measurement. (same applies to the opposite situation when the gain is set to low and the next measurement is in a dark site). Please note that a gain switch happens when your measurement site has very large light differences e.g. you took a measurement inside your room and then took the next one out, pointing at the night sky)
6. Uranus quickly takes measurements and calculates an average value.
7. OLED display turns on and shows all calculated results (check the image below).



- **MPSAS**: Magnitudes are a measurement of an object's brightness. The term arcsecond comes from an arc being divided up into seconds. There are 360 degrees in a circle, and each degree is divided into 60 minutes. Each minute is divided into 60 seconds. A square arc second has an angular area of one second by one second. The term magnitudes per square arc second means that the brightness in magnitudes is spread out over a square arcsecond of the sky. If the SQM provides a reading of 21.00, that would be like saying that a light of a 21th magnitude star brightness was spread over one square arcsecond of the sky.

- **NELM**: There are a variety of ways of measuring your night sky quality, and one of the most effective ways is by looking for the faintest star you can find with your naked eye and noting its brightness, or magnitude. This provides what is known as Naked Eye Limiting Magnitude, NELM. Naked Eye Limiting Magnitude or NELM represents the faintest magnitude that your naked eye can see in the conditions being measured. A NELM of 6.0 means you will be able to see objects as faint as magnitude 6.0; this is about as faint as the human eye can see. On the other hand, a NELM of 2.0 means the sky is relatively bright. This could be due to the moon or your location, say in an urban area with lots of light pollution.

- **LUX**: The lux is the unit of illuminance in the International System of Units (SI). It is defined in terms of lumen s per meter squared (lm/m^2). Lux describes how much light falls on a certain area.

Store - On-demand page (Press **Store [<<]** button for 2 seconds)

All sensor values are stored in internal memory. Uranus displays a confirmation screen with the memory bank number that was used. In the above example, Uranus has 42 used out of 500 available records in memory. Press any button to exit this screen.

MEASUREMENT CONSIDERATIONS

1.21 SKY QUALITY

MPSAS is a logarithmic measurement scale which means that large changes in sky brightness correspond to relatively small numerical changes. A difference of 5 magnitudes is a factor of 100 times the intensity.

Lots of factors can affect each light measurement. Let apart the light pollution for obvious reasons. In different dark sites, you have to calculate that the below reasons affect each light measurement.

- Zodiac Light: A white glow that is visible in the night sky and appears to extend from the Sun's direction and along the zodiac, straddling the ecliptic. Sunlight scattered by interplanetary dust particles causes this phenomenon. Zodiacal light is best seen in the Northern Hemisphere during twilight after sunset in spring and before sunrise in autumn, and before sunrise in autumn and after sunset in the Southern, when the zodiac is at a steep angle to the horizon. However, the glow is so faint that moonlight or light pollution often outshines it, rendering it visible only in dark skies. Zodiac Light will affect the light measurement (increases brightness) to lower MPSAS values (in dark skies) if you point towards this direction.
- Milky Way Galaxy: will increase brightness if you point towards the Milky Way region.
- Airglow: or nightglow is a faint emission of light by a planetary atmosphere. In the case of Earth's atmosphere, this optical phenomenon causes the night sky never to be completely dark, even after the effects of starlight and diffused sunlight from the far side are removed. This phenomenon originates with self-illuminated gases and it has no relationship with Earth's magnetism and sunspot activity. Airglow is caused by various processes in the upper atmosphere of Earth, such as the recombination of atoms that were photoionized by the Sun during the day, luminescence caused by cosmic rays striking the upper atmosphere, and chemiluminescence caused mainly by oxygen and nitrogen reacting with hydroxyl free radicals at heights of a few hundred kilometers. Airglow at night may be bright enough for a ground observer to notice and appears generally bluish. Although airglow emission is fairly uniform across the atmosphere, it appears brightest at about 10° above the observer's horizon, since the lower one looks, the greater the mass of the atmosphere one is looking through, Airglow during your night will affect the measurement of your MPSAS. (On different nights you will see fluctuations in the light readout caused by this – and not only- effect)
- Moisture or fog: reflects artificial light to the ground and increases brightness.
- Aurora in places closer to the north and south pole: is the result of disturbances in the magnetosphere caused by the solar wind. Major disturbances result from enhancements in the speed of the solar wind from coronal holes and coronal mass ejections. These disturbances alter the trajectories of charged particles in the magnetospheric plasma. These particles, mainly electrons and protons,

precipitate into the upper atmosphere (thermosphere/exosphere). The resulting ionization and excitation of atmospheric constituents emit light of varying color and complexity. The form of the aurora, occurring within bands around both polar regions, also depends on the acceleration imparted to the precipitating particle's glow. Aurora increases brightness measurement in a factor that a light measurement is useless.

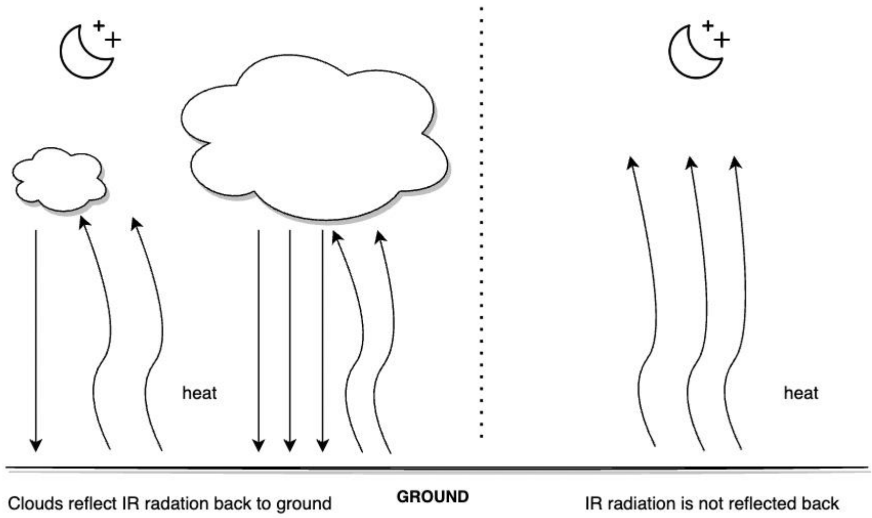
- Dust: can decrease the brightness by hiding stars or increase brightness by reflecting light to the ground. E.g., Dust from the Sahara Desert is transferred to all continents and affects the light measurements.
- Clouds: High cloud layers or low clouds can decrease brightness by hiding stars.
- Moon: Visibility % and position in the night sky

Other obstacles such as building walls or people close to the angle of sensor measurement can also affect the light sensor readout. Please, make sure that your field of view is clear from any obstacles.

1.22 CLOUD COVERAGE

To determine the cloud coverage, you need to calculate the Sky temperature. The actual sky temperature can be calculated by subtracting the ambient temperature from the infrared-measured temperature.

Clouds reflect the infrared radiation of the ground back to earth, The lower the difference in Ground vs Sky temperature, the more the clouds in the sky. If the difference is high, then this is a sign that the infrared radiation is not reflecting to earth.



Lots of factors affect the actual sky temperature. Your geographical latitude, the season, the ambient temperature, and conditions in the troposphere will shift the sky temperature so a correction model is automatically applied by the Uranus device.

One of the most important factors is the ambient temperature which is taken into consideration by the device and adjusts the actual temperature sky readout. The temperature difference in cold vs hot climates (or winter vs summer) plays a significant role in the calculation and makes this crucial to determine if the sky is clear or has sparse clouds.

Overcast skies tend to differ more between the winter and summer months with those in winter tending to be quite a few degrees colder. This is usually because the cloud base is at or near the same temperature as the ground temperature in the respective season. So, a typical summer cloud base temperature might find itself at 12°C; a winter cloud base temperature at -2°C.

In essence, the temperature gap between clear skies and cloudy skies is not a straightforward relationship. It depends very much on the season and local variation.

Uranus measures the cloud IR temperature and compares it with the ground ambient temperature. The higher the difference (ΔT), the less the clouds. Usually, a difference above 30 degrees indicates a clear sky.

The cloud sensing model can be configured/tuned from Unity software by pushing to the Uranus device the temperature difference value in which the sky is clear, in your site.

As noted, the season (winter or summer), your local variation, and other conditions can severely affect this model. Fortunately, it is pretty straightforward and the tuning of the cloud sensing model can output reliable examples between clear, light clouds, sparse clouds and overcast sky.

CONFIGURATION CHANGES

These configuration changes are applied from supplied (Unity) software.

1.23 SET UNITS

Select Metric or Imperial Units. This setting is applied only to on-screen displays. The change of units in software is independent of what the device reports on its display.

1.24 SET TIMEZONE

Select your time zone offset. This setting is needed to display your local date and time. Also, it is required to calculate the moon's visibility, age, and astronomical sunrise and sunset time.

1.25 SET SLEEP AFTER

Select a range of 1 to 30 minutes. This is the time interval (in minutes) that your device will go to sleep mode after button inactivity. (USB operation ignores this value and keeps the device always up and running)

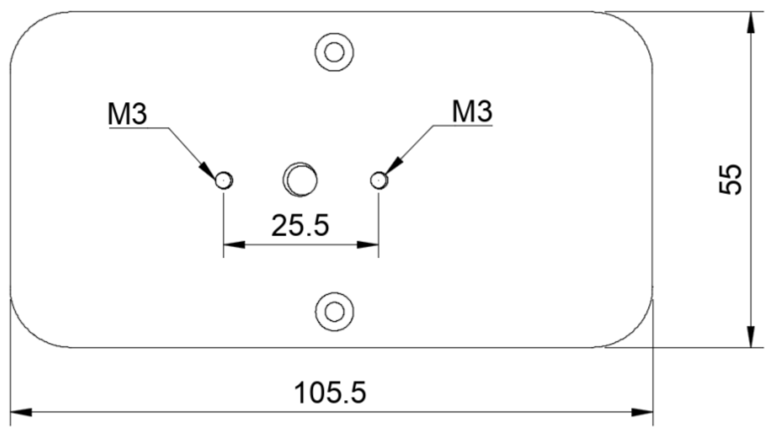
1.26 SET LIGHT READOUT OFFSET

Set a readout offset (-999 to +999) to properly configure the Sky Quality Light sensor. This value is **multiplied by 0.01** and applied to the measured light (MPSAS) scale. E.g to increase the MPSAS readout to 0.2 you need to set the SQM offset to 20.

1.27 SET INFRARED SENSOR EMISSIVITY

Emissivity is a relative measure of how efficiently an object radiates heat. A perfect thermal emitter has an emissivity of 1.0, but most real-world objects range from 0 to 1. For example, human skin has an emissivity of about 0.98. Shiny metals have a very low emissivity, for example, polished aluminum has an emissivity of 0.05. Painted aluminum has an emissivity of 0.45. In the cloud detection algorithm, we use an emissivity of 1.0. Emissivity value can be configured from Unity Platform software.

DIMENSIONS

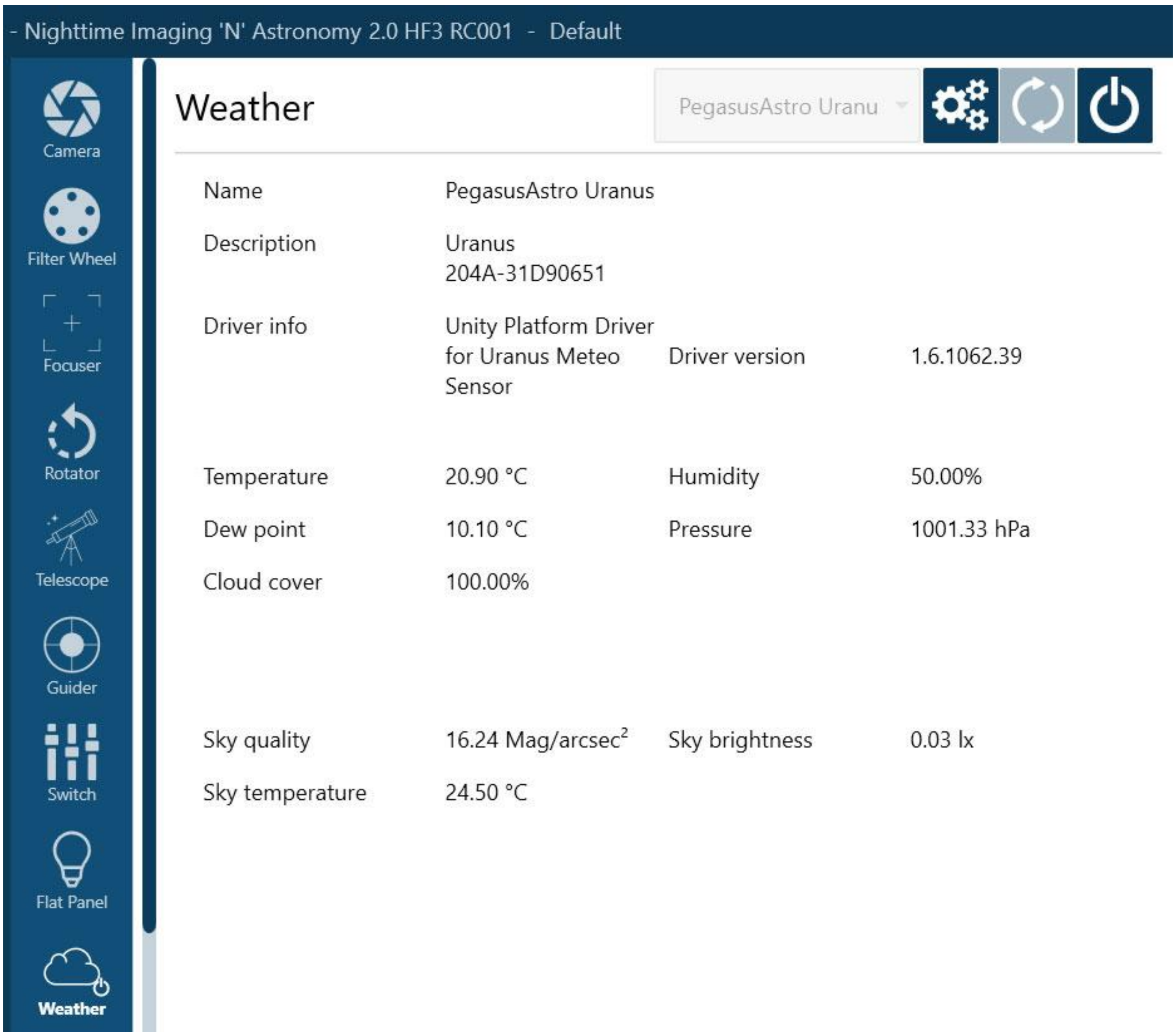


Back of device - Units in mm

ASCOM 6 HOWTO

Uranus Meteo Sensor fully supports ASCOM 6 Observing Conditions. Metrics can be easily displayed to imaging software such as N.I.N.A. or SGPro.

Select the "Pegasus Astro Uranus" ASCOM driver in your preferable software and connect to the device. Instantly you will see all sensor readings that are continuously updating every second.



TECHNICAL SPECIFICATION

Size	105.5 x 55 x 24 mm
Weight	175 grams
Battery	NiMH 600mA rechargeable (3xAAA)
Communication	USB type C socket (also for battery charging)
GPS Output	NMEA 6P4C socket (10Micron pinout compatible)
Buttons	2 x Push buttons on top
Reset Button	On the side of the device
Power Consumption	3.3V / 60mA during operation, 10µA during sleep
Temperature Sensor	-40 to 85°C, Accuracy +- 0.5° C
Humidity Sensor	0 % to 100 %, +-3 % Relative Humidity
Cloud Sensor	IR Sensor 60° wide
Light Sensor	Digital CMOS integrated circuit. Measures visible plus infrared light. 600M:1 Dynamic Range
GPS Receiver	High sensitivity GNSS Module with 88 Channels, Ultra-Low Consumption Fast Positioning
Pressure Sensor	Pressure: 300 to 1100 hPa
Operating Temperature	-30° to +60 °C
Operation	Digital

ENVIRONMENT

The electronics and materials of the device have been carefully selected so the device can operate at temperatures from -30 °C to +60 °C and humidity up to 99%

WARRANTY

The device is covered by two years of warranty.

SUPPORT

For any issues, questions or feedback and recommendations please contact us via email: support@pegasusastro.com