



METER

INTEGRATOR'S GUIDE ATMOS 41 COMPACT WEATHER STATION

SENSOR DESCRIPTION

The ATMOS 41 Compact Weather Station is designed for continuous monitoring of environmental variables, including all standard weather measurements (see [Measurement Specifications on page 2](#)). All sensors are integrated into a single unit, requiring minimal installation effort. Ultra-low power consumption and a robust, no moving parts design that prevents errors because of wear or fouling, make the ATMOS 41 ideal for long-term, remote installations.

APPLICATIONS

- Weather monitoring
- Microenvironment monitoring
- Spatially distributed environmental monitoring
- Crop weather monitoring
- Fire danger monitoring/mapping
- Weather networks

ADVANTAGES

- Robust, no moving parts design
- Small form factor
- Integrated design for easy installation
- Low input voltage requirements
- Low power design supports battery-operated data loggers
- Supports the SDI-12 three-wire interface
- Tilt meter informs user of out-of-level condition
- No configuration necessary
- Measures all standard weather variables (plus several others)

PURPOSE OF THIS GUIDE

METER provides the information in this integrator's guide to help ATMOS 41 Compact Weather Station customers establish communication between these sensors and their data acquisition equipment or field data loggers. Customers using data loggers that support SDI-12 sensor communications should consult the data logger user's manual. METER sensors are fully integrated into the METER system of plug-and-play sensors, cellular-enabled data loggers, and data analysis software.

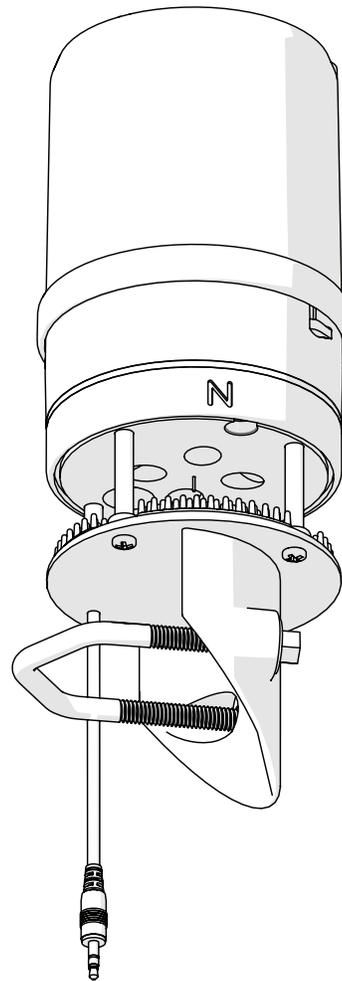


Figure 1 ATMOS 41 Compact Weather Station

Firmware Version	Description of Changes
4.49	New release

SPECIFICATIONS

MEASUREMENT SPECIFICATIONS

Solar Radiation		Wind Gust	
Range:	0 to 1750 W/m ²	Range:	0 to 40 m/s
Resolution:	1 W/m ²	Resolution:	0.01 m/s
Accuracy:	±5% of measurement typical	Accuracy:	The greater of 0.3 m/s or 3% of measurement
Precipitation		Wind Direction	
Range:	0 to 125 mm/h	Range:	0 to 359°
Resolution:	0.017 mm	Resolution:	1°
Accuracy:	±5% of measurement from 0 to 50 mm/h	Accuracy:	±5°
Vapor Pressure		Compass Heading	
Range:	0 to 47 kPa	Range:	0 to 359°
Resolution:	0.01 kPa	Resolution:	1°
Accuracy:	Varies with temperature and humidity, ±0.2 kPa typical below 40 °C	Accuracy:	±5°
Relative Humidity		Tilt	
Range:	0 to 100%	Range:	0 to 180°
Resolution:	0.1%	Resolution:	0.1°
Accuracy:	Varies with temperature and humidity, ±3% RH typical	Accuracy:	±1°
Air Temperature		Lightning Strike Count	
Range:	-40 to 50 °C	Range:	0 to 65535 strikes
Resolution:	0.1 °C	Resolution:	1 strike
Accuracy:	±0.6 °C	Accuracy:	Variable with distance, >25% detection at <10 km typical
Humidity Sensor Temperature		Lightning Average Distance	
Range:	-40 to 50 °C	Range:	0 to 40 km
Resolution:	0.1 °C	Resolution:	3 km
Accuracy:	±1.0 °C	Accuracy:	Variable
Barometric Pressure		Dimensions	
Range:	50 to 110 kPa	10 cm diameter x 34 cm height (includes rain gauge filter)	
Resolution:	0.01 kPa	Cable Length	
Accuracy:	±0.1 kPa	3 m (custom cable lengths are available for an additional cost)	
Horizontal Wind Speed			
Range:	0 to 40 m/s		
Resolution:	0.01 m/s		
Accuracy:	The greater of 0.3 m/s or 3% of measurement		

ELECTRICAL AND TIMING CHARACTERISTICS

Supply Voltage (VCC) to GND		Operating Temperature Range	
Minimum	3.6 V	Minimum	-40 °C
Typical		Typical	
Maximum	15.0 V	Maximum	50 °C
Digital Input Voltage (logic high)		Power Up Time (SDI Ready)—aRx! Commands	
Minimum	2.8 V	Minimum	
Typical	3.0 V	Typical	10 s
Maximum	15.0 V	Maximum	
Digital Input Voltage (logic low)		Power Up Time (SDI Ready)—Other Commands	
Minimum	-0.3 V	Minimum	
Typical	0.0 V	Typical	800 ms
Maximum	0.8 V	Maximum	
Power Line Slew Rate		Measurement Duration	
Minimum	1.0 V/ms	Minimum	
Typical		Typical	110 ms
Maximum		Maximum	3000 ms
Current Drain (during measurement)		COMPLIANCE	
Minimum	0.2 mA	Manufactured under ISO 9001:2015	
Typical	8.0 mA	EM ISO/IEC 17050:2010 (CE Mark)	
Maximum	16.0 mA		
Current Drain (while asleep)			
Minimum	0.2 mA		
Typical	0.3 mA		
Maximum	0.4 mA		

EQUIVALENT CIRCUIT AND CONNECTION TYPES

Refer to [Figure 2](#) and [Figure 3](#) to connect the ATMOS 41 to a logger. [Figure 2](#) provides a low-impedance variant of the recommended SDI-12 specification.

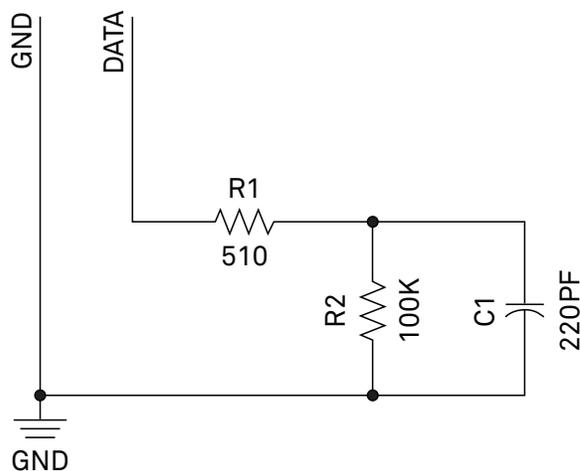


Figure 2 Equivalent circuit diagram

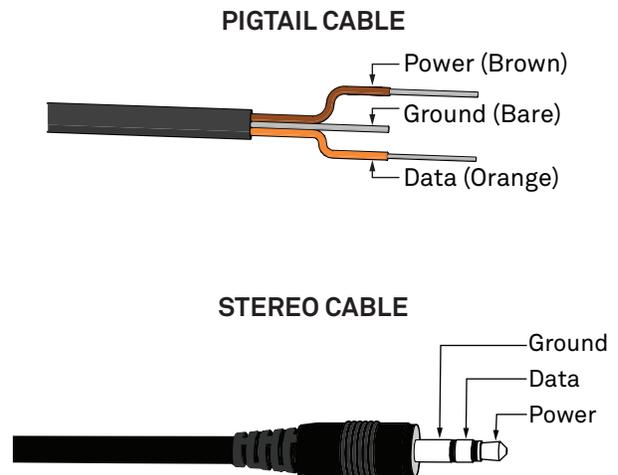


Figure 3 Connection types

⚠ SAFETY PRECAUTIONS

METER sensors are built to the highest standards, but misuse, improper protection, or improper installation may damage the sensor and possibly void the warranty. Before integrating sensors into a sensor network, follow the recommended installation instructions and implement safeguards to protect the sensor from damaging interference.

SURGE CONDITIONS

Sensors have built-in circuitry that protects them against common surge conditions. Installations in lightning-prone areas, however, require special precautions, especially when sensors are connected to a well-grounded third-party logger.

Visit www.metergroup.com for articles containing more information.

CABLES

Improperly protected cables can lead to severed cables or disconnected sensors. Cabling issues can be caused by many factors, including rodent damage, driving over sensor cables, tripping over the cable, not leaving enough cable slack during installation, or poor sensor wiring connections. To relieve strain on the connections and prevent loose cabling from being inadvertently snagged, gather and secure the cable travelling between the ATMOS 41 and the data acquisition device to the mounting mast in one or more places. Install cables in conduit or plastic cladding when near the ground to avoid rodent damage. Tie excess cable to the data logger mast to ensure cable weight does not cause sensor to unplug.

SENSOR COMMUNICATIONS

METER digital sensors feature a 3-wire interface following SDI-12 protocol for communicating sensor measurements.

SDI-12 INTRODUCTION

SDI-12 is a standards-based protocol for interfacing sensors to data loggers and data acquisition equipment. Multiple sensors with unique addresses can share a common 3-wire bus (power, ground, and data). Two-way communication between the sensor and logger is possible by sharing the data line for transmit and receive as defined by the standard. Sensor measurements are triggered by protocol command. The SDI-12 protocol requires a unique alphanumeric sensor address for each sensor on the bus so that a data logger can send commands to and receive readings from specific sensors.

Visit www.sdi-12.org/archives.php to download the latest SDI-12 Specification v1.3 and learn more about the SDI-12 protocol.

DDI SERIAL INTRODUCTION

The DDI (Decagon Devices, Inc.) serial protocol is the method used by the METER family of data loggers for collecting data from the sensor. This protocol uses the data line configured to transmit data from the sensor to the receiver only (simplex). Typically, the receive side is a microprocessor UART or a general-purpose IO pin using a bitbang method to receive data. Sensor measurements are triggered by applying power to the sensor. When the ATMOS 41 is set to address 0, a DDI serial string is sent on power up identifying the sensor.

INTERFACING THE SENSOR TO A PC

The serial signals and protocols supported by the sensor require some type of interface hardware to be compatible with the serial port found on most personal computers (or USB-to-serial adapters). There are several SDI-12 interface adapters available in the marketplace; however, METER has not tested any of these interfaces and cannot make a recommendation as to which adapters work with METER sensors. METER data loggers and the ProCheck hand-held device can operate as a computer-to-sensor interface for making on-demand sensor measurements. For more information, please contact [Customer Support](#).

METER SDI-12 IMPLEMENTATION

METER sensors use a low-impedance variant of the SDI-12 standard sensor circuit (Figure 2). During the power-up time, sensors output some sensor diagnostic information and should not be communicated with until the power-up time has passed. After the power up time, the sensors are fully compatible with all commands listed in the SDI-12 Specification v1.3 except for the continuous measurement commands (aR0–aR9 and aRC0–aRC9) and the concurrent measurement commands (aC–aC9 and aCC0–aCC9). **M** and **R** command implementations are found on pages 7–9.

Out of the factory, all METER sensors start with SDI-12 address 0 and print out the DDI serial startup string during the power up time. This can be interpreted by non-METER SDI-12 sensors as a pseudo-break condition followed by a random series of bits.

The ATMOS 41 Compact Weather Station will omit the DDI serial startup string (sensor identification) when the SDI-12 address is nonzero.

SENSOR BUS CONSIDERATIONS

Because of the complexity and substantial number of measurements, it is advised to avoid using the ATMOS 41 in a bus configuration. The recommended usage is to connect it to a dedicated port on the logger.

If a bus configuration is the only option for the system, please contact METER [Customer Support on page 11](#).

SDI-12 CONFIGURATION

Table 1 lists the SDI-12 communication configuration.

Table 1 SDI-12 communication configuration

Baud Rate	1200
Start Bits	1
Data Bits	7 (LSB first)
Parity Bits	1 (even)
Stop Bits	1
Logic	Inverted (active low)

SDI-12 TIMING

All SDI-12 commands and responses must adhere to the format in Figure 4 on the data line. Both the command and response are preceded by an address and terminated by a carriage return line feed combination and follow the timing shown in Figure 5.

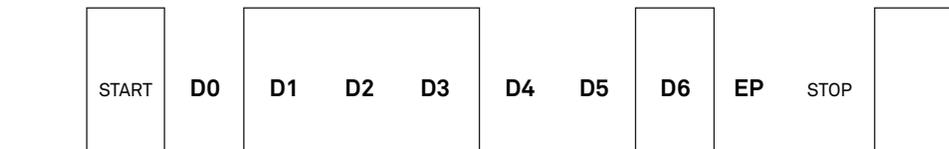


Figure 4 Example SDI-12 transmission of the character 1 (0x31)

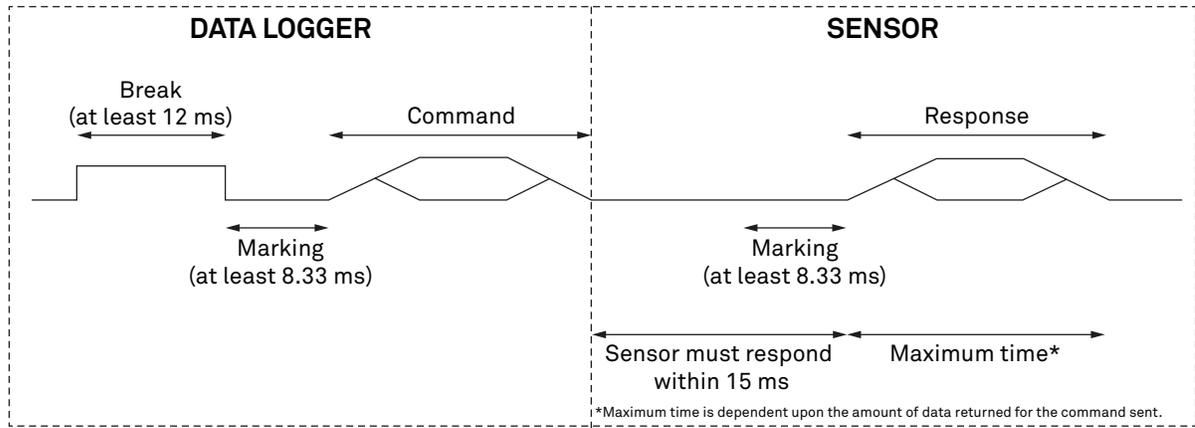


Figure 5 Example data logger and sensor communication

COMMON SDI-12 COMMANDS

This section includes tables of common SDI-12 commands that are often used in an SDI-12 system and the corresponding responses from METER sensors.

INFO COMMAND (aI!)

The information command can be used to obtain a variety of detailed information about the connected sensor. An example of the command and response is shown below, where the command is in bold and the response follows the command.

Table 2 INFO COMMAND (aI!)

PARAMETER	FIXED CHARACTER LENGTH	DESCRIPTION
1I! 13METER_ _ _ _ATM41_ 404631800001		
1I!	3	Data logger command. Request to the sensor for information from sensor address 1.
1	1	Sensor address. Prepended on all responses, this indicates which sensor on the bus is returning the following information.
13	2	Indicates that the target sensor supports SDI-12 Specification v1.3 (2 characters)
METER_ _ _ _	8	Vendor identification string (METER and three spaces _ _ _ for all METER sensors)
ATM41_	6	Sensor model string. This string is specific to the sensor type. For the ATMOS 41, the string is ATM41 _.
404	3	Sensor version. This number divided by 100 is the METER sensor version (e.g., 404 is version 4.04).
631800001	≤13 Variable	Sensor serial number. This is a variable length field. It may be omitted for older sensors.

CHANGE ADDRESS COMMAND (aAB!)

The Change Address command is used to change a sensor address to a new address. All other commands support the wildcard character as the target sensor address except for this command. All METER sensors have a default address of 0 (zero) out of the factory. Supported addresses are alphanumeric (i.e., a–z, A–Z, and 0–9). An example output from a METER sensor is shown in [Table 3](#) where the command is in **bold** and the response follows the command.

Table 3 CHANGE ADDRESS COMMAND (aAB!)

PARAMETER	FIXED CHARACTER LENGTH	DESCRIPTION
1A0!0		
1A0!	4	Data logger command. Request to the sensor to change its address from 1 to a new address of 0.
0	1	New sensor address. For all subsequent commands, this new address will be used by the target sensor.

ADDRESS QUERY COMMAND (?!)

While disconnected from a bus, the Address Query command can be used to determine which sensors are currently being communicated with. Sending this command over a bus will cause a bus contention where all the sensors will respond simultaneously and corrupt the data line. This command is helpful when trying to isolate a failed sensor. Below is an example of the command and response, where the command is in bold and the response follows the command. The question mark (?) is a wildcard character that can be used in place of the address with any command except the Change Address command.

Table 4 ADDRESS QUERY COMMAND (?!)

PARAMETER	FIXED CHARACTER LENGTH	DESCRIPTION
?!0		
?!	2	Data logger command. Request for a response from any sensor listening on the data line
0	1	Sensor address. Returns the sensor address to the currently connected sensor.

MEASUREMENT TIMING

While powered up, the ATMOS 41 takes solar radiation, precipitation, wind, and air temperature measurements every 10 s and stores the values internally. Orientation, compass, vapor pressure, atmospheric pressure, and relative humidity measurements are taken every 60 s and are also stored internally. aM!, aR0!, and aR3! commands (and subsequent D commands when necessary) will compute the averages, accumulations, or maximums of these measurements and reset internal averaging counters and accumulators in preparation for any subsequent measurement command. The aR4! command will output instantaneous measurements of these parameters and must be used at intervals of 10 s or greater for the response to be returned within the SDI-12 specification of 15.0 ms.

The following tables list the relevant **M** and **R** commands and subsequent **D** commands when necessary.

MEASUREMENT COMMAND IMPLEMENTATION

Measurement (**M**) commands are sent to a single sensor on the SDI-12 bus and require that subsequent Data (**D**) commands are sent to that sensor to retrieve the sensor output data before initiating communication with another sensor on the bus.

Please refer to command [Table 5](#) and [Table 6](#) for an explanation of the command sequence and see [Table 11 Parameter Descriptions on page 9](#) for an explanation of response parameters.

Table 5 aM! COMMAND SEQUENCE

COMMAND	RESPONSE
This command reports average values when relevant.	
aM!	Attn
aD0!	a<solar>+<precipitation>+<strikes>
aD1!	a<windSpeed>+<windDirection>+<gustWindSpeed>
aD2!	a±<airTemperature>+<vaporPressure>+<atmosphericPressure>

NOTE: The measurement and corresponding data commands are intended to be used back to back. After a measurement command is processed by the sensor, a service request a <CR><LF> is sent from the sensor signalling the measurement is ready. Either wait until *ttt* seconds have passed or wait until the service request is received before sending the data commands. See the [SDI-12 Specifications v1.3](#) document for more information.

Table 6 aM1! COMMAND SEQUENCE

COMMAND	RESPONSE
This command reports instantaneous values.	
aM1!	attn
aD0!	a±<xOrientation>±<yOrientation>+<compassHeading>

NOTE: The measurement and corresponding data commands are intended to be used back to back. After a measurement command is processed by the sensor, a service request a <CR><LF> is sent from the sensor signalling the measurement is ready. Either wait until *ttt* seconds have passed or wait until the service request is received before sending the data commands. See the [SDI-12 Specifications v1.3](#) document for more information.

CONCURRENT MEASUREMENT COMMANDS IMPLEMENTATION

Concurrent (C) commands are typically used with sensors connected to a bus. Due to the complexity of the measurement scheme in this sensor and how the SDI-12 communication is affected by it, using the ATMOS 41 in a bus configuration is not recommended. As a consequence, C commands are not supported.

CONTINUOUS MEASUREMENT COMMANDS IMPLEMENTATION

Continuous (R) commands trigger a sensor measurement and return the data automatically after the readings are completed without needing to send a D command.

The aR3! and aR4! commands must be used at intervals of 10 s or greater for the response to be returned within 15.0 ms as defined in the SDI-12 standard.

aR0!, aR3!, and aR4! return more characters in their responses than the 75 character limitation called out in the [SDI-12 Specification v1.3](#). It is recommended to use a buffer that can store at least 116 characters.

Please refer to [Table 7](#) through [Table 10](#) for an explanation of the command sequence and see [Table 11 Parameter Descriptions on page 9](#) for an explanation of response parameters.

Table 7 aR0! MEASUREMENT COMMAND SEQUENCE

COMMAND	RESPONSE
This command reports average values.	
aR0!	a+<solar>+<precipitation>+<strikes>+<strikeDistance>+<windSpeed> +<windDirection>+<gustWindSpeed>±<airTemperature>+<vaporPressure> +<atmosphericPressure>+<relativeHumidity>±<humiditySensorTemperature> ±<xOrientation>±<yOrientation>+<compassHeading>±<NorthWindSpeed> ±<EastWindSpeed>

NOTE: This command does not adhere to the SDI-12 response timing. See [METER SDI-12 Implementation on page 5](#) for more information.

Table 8 aR1! MEASUREMENT COMMAND SEQUENCE

COMMAND	RESPONSE
This command reports average values.	
aR1!	a<xOrientation>±<yOrientation>±<compassHeading>

NOTE: This command does not adhere to the SDI-12 response timing. See [METER SDI-12 Implementation on page 5](#) for more information.

Table 9 aR3! MEASUREMENT COMMAND SEQUENCE

COMMAND	RESPONSE
This command reports average values.	
aR3!	a<TAB><solar> <precipitation> <strikes> <strikeDistance> <NorthWindSpeed> <EastWindSpeed> <gustWindSpeed> <airTemperature> <vaporPressure> <atmosphericPressure> <xOrientation> <yOrientation> <compassHeading> <humiditySensorTemperature><CR><sensortype><Checksum>

NOTE: This command does not adhere to the SDI-12 response format. However, it does adhere to SDI-12 timing if it is sent at intervals ≥ 10 s. See [METER SDI-12 Implementation on page 5](#) for more information.

Table 10 aR4! MEASUREMENT COMMAND SEQUENCE

COMMAND	RESPONSE
This command reports instantaneous values.	
aR4!	a<TAB><solar> <precipitation> <strikes> <strikeDistance> <NorthWindSpeed> <EastWindSpeed> <gustWindSpeed> <airTemperature> <vaporPressure> <atmosphericPressure> <xOrientation> <yOrientation> <compassHeading> <humiditySensorTemperature><CR><sensortype><Checksum>

NOTE: This command does not adhere to the SDI-12 response format. However, it does adhere to SDI-12 timing if it is sent at intervals ≥ 10 s. See [METER SDI-12 Implementation on page 5](#) for more information.

Table 11 Parameter Descriptions

PARAMETER	UNIT	DESCRIPTION
±	—	Positive or negative sign denoting sign of the next value.
a	—	SDI-12 address
n	—	Number of measurements (fixed width of 1)
nn	—	Number of measurements with leading zero if necessary (fixed width of 2)
ttt	sec	Maximum time measurement will take (fixed width of 3)
<TAB>	—	Tab character
<CR>	—	Carriage return character
<LF>	—	Line feed character
<solar>	W/m ²	Solar radiation (average since the last measurement or instantaneous value depending on SDI-12 command used)
<precipitation>	mm	Rainfall in millimeters since the last measurement
<strikes>	—	Number of lightning strikes detected since last measurement
<strikeDistance>	km	Average strike distance from sensor since last measurement
<NorthWindSpeed>	m/s	Wind speed from the northerly direction (negative values denote southerly direction) (average since the last measurement or instantaneous value depending on SDI-12 command used)

Table 11 Parameter Descriptions

PARAMETER	UNIT	DESCRIPTION
<EastWindSpeed>	m/s	Wind speed from the easterly direction (negative values denote westerly direction) (average since the last measurement or instantaneous value depending on SDI-12 command used)
<windSpeed>	m/s	Combined wind speed magnitude of the <NorthWindSpeed> and <EastWindSpeed> (average since the last measurement or instantaneous value depending on SDI-12 command used)
<gustWindSpeed>	m/s	Maximum measured <windSpeed> since the last measurement
<windDirection>	°	Wind heading clockwise from north reference (average since the last measurement or instantaneous value depending on SDI-12 command used)
<airTemperature>	°C	Air temperature (average since the last measurement or instantaneous value depending on SDI-12 command used)
<vaporPressure>	kPa	Vapor pressure (average since the last measurement or instantaneous value depending on SDI-12 command used)
<atmosphericPressure>	kPa	Atmospheric pressure (average since the last measurement or instantaneous value depending on SDI-12 command used)
<relativeHumidity>	RH	Relative humidity as computed with either average or instantaneous values of <vaporPressure> and <airTemperature>, depending on SDI-12 command used
<humiditySensor Temperature>	°C	Internal temperature measured with the relative humidity sensor (average since the last measurement or instantaneous value depending on SDI-12 command used)
<xOrientation>	°	X orientation angle (zero is level) (last measured value)
<yOrientation>	°	Y orientation angle (zero is level) (last measured value)
<compassHeading>	°	Compass heading clockwise from north reference (last measured value)
<sensortype>	—	ASCII character denoting the sensor type. For ATMOS 41, the character is the right square bracket] character
<Checksum>	—	METER serial checksum

COMPASS CONFIGURATION COMMAND (?XG!)

When this setting is set to one, the wind direction is corrected for magnetic north. To correct to true north, an offset in software to correct the data from magnetic declination at the installation location is required. Setting this value to 0 (default condition) disables the correction and requires that the sensor be oriented to north according to the **N** on the sensor housing. Below are examples of the commands and responses, where the commands are in bold and the responses follow the commands.

NOTE: Mounting the ATMOS 41 on ferrous (magnetic) hardware will invalidate the compass heading, so instruments mounted on steel poles should have the compass correction disabled.

To get the magnetic north correction setting for wind direction state:

aXg!a_1

To disable the magnetic north correction for wind direction:

aXg0!aOK

To enable the magnetic north correction for wind direction:

aXg1!aOK

Table 12 ?Xg! COMPASS CONFIGURATION COMMAND

PARAMETER	FIXED CHARACTER LENGTH	DESCRIPTION
a	1 Char	SDI-12 address. In this case the sensor's SDI-12 address is a.
Xg	3 Chars	Compass configuration command.
1	1 Char	Magnetic north correction for wind direction state. 1 = correction is enabled, 0 = correction is disabled. If this value is omitted, then the current setting is returned.
!	1 Char	Termination character for command.

NOTE: If an invalid parameter is passed in, ERROR will be returned instead of OK.

METER SERIAL CHECKSUM

Here is an example of how to calculate the checksum (crc) in C. In this case, the string passed to the function is `<tab>0<0D>` and the returning value is the character C. This checksum is used in the continuous commands R3 and R4.

```
char LegacyChecksum(char * Response)
{
    int length, sum = 0, i, crc;

    // Finding the length of the response string
    length = strlen(Response);

    // Adding characters in the response together
    for( i = 0; i < length; i++){
        sum += Response[i];
    }

    // Converting checksum to a printable character
    crc = sum % 64 + 32;

    return crc;
}
```

CUSTOMER SUPPORT

Customer service representatives are available for questions, problems, or feedback Monday through Friday, 8 am–5 pm Pacific time.

Email: support.environment@metergroup.com
sales.environment@metergroup.com

Phone: +1.509-332-5600

Website: www.metergroup.com

If contacting METER by email, please include the following information:

<i>Name</i>	<i>Instrument serial number</i>
<i>Address</i>	<i>Description of problem</i>
<i>Phone number</i>	

NOTE: For ATMOS 41 weather stations purchased through a distributor, please contact the distributor directly for assistance.