MICROAGROVOLT –WEATHER STATIONS FOR MONITORING OF AGRIVOLTAIC PLANTS (Rev.0 100125)

Description

MicroAGROVOLT weather stations have been designed and built to continuously detect weather and climate conditions that can influence the performance of a photovoltaic system and the growth of an agricultural crop.

The **monitoring of the photovoltaic plant** is carried out in compliance with IEC 61724, CEI 82-25 and IEC 60904 standards using ISO9060 radiometric instrumentation. Typically, the measurements detected are:

- solar radiation
- air and photovoltaic panel temperature
- wind intensity (optionally also the direction if there are mobile solar tracking systems)

The **monitoring of the crop** is carried out in compliance with WMO (World Meteorological Organization) standards using weather and climate instrumentation aimed primarily at preventing water stress and plant diseases. For the prevention of **water stress**, the following measurements are usually taken:

- soil temperature and humidity
- calculation of plant evapotranspiration by applying the FAO-WMO formula (implemented in Geoves dataloggers) which uses measurements of solar radiation, air temperature-humidity, wind speed, pressure and atmospheric precipitation

For the **prevention of plant diseases**, the following measurements are taken:

- air temperature and humidity
- leaf wetness
- atmospheric precipitation

Since the weather station can be customized as desired, you can choose which parameters to provide based on the needs of each plant. In its **complete configuration** for monitoring **both the photovoltaic system and the crop**, the MicroAGROVOLT station will detect the following measurements:

1. solar radiation
2. air temperature and humidity
3. photovoltaic panel temperature
4. soil temperature and humidity
5. wind intensity (optionally also the direction for mobile solar tracking systems)
6. atmospheric pressure
7. atmospheric precipitation
8. leaf wetness
9. calculation of plant evapotranspiration by applying the FAO-WMO formula (using the Geoves datalogger and the measurements referred to in points 1-2-5-6-7)

Each station can be equipped with a Geoves datalogger for data acquisition, display, storage and transmission which can occur in the following ways:

1) Via **LAN/ethernet** cable with free Geodesk software for data download installed on the system's central PC;
2) **GPRS** wireless with transfer to a protected web area (**FTP** area) and the possibility of managing data from a web service;
3) manually with data download in CSV format from **SD Card memory**;

Alternatively, or in addition to the datalogger, the instantaneous data of each meteorological measurement can be available on **ModBus** RS485 Slave or TCP/IP output for connection to external SCADA.

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ADVANTAGES and MAIN FEATURES

Compliance

- ✓ Dataloggers and measuring station: **IEC 61724, CEI 82-25 and IEC 60904**
- ✓ Pyranometers and radiometers: **ISO 9060, ISO 17025 and WMO**
- ✓ Meteorological sensors: **WMO Annex 8**

Precision, Reliability and Robustness

- ✓ Measurement sampling time of 1 second with data storage **every 5 (default), 10-15-30-60'**
- ✓ Certificability of meteorological-radiometric sensors at recognized external laboratories (**Accredia, WMO, Measnet**, etc.)
- ✓ Instrumentation, cables, supports and datalogger housing boxes made of **stainless materials** resistant to any operating condition (direct radiation, temperature variations, salinity, sand, gusts of wind, hail, etc.)

Versatility, compatibility and ease of use

- ✓ Data storage in **standard TXT text format** with comma-separated fields (**CSV format**)
- ✓ **Automated GPRS antenna pointing** by datalogger with on-site reception signal verification
- ✓ **Display** of measurements with easy functional verification

Other features

- ✓ Completely Italian technology and minimal maintenance
- ✓ After-sales assistance for maintenance and any calibrations

Technical Data of the weather station mod. MicroAGROVOLT

DATALOGGER	mMET3 – Multichannel Datalogger
I/O Channels	**8 analog inputs** (+ 8 option on Expa8 interface): in voltage or current (typ.0…5Vdc or 4…20mA); **2 insulated digital inputs (pulse counter)** for sensors with "high" frequency up to 50KHz (anemometers, flow gauges, ecc…) and with "low" frequency output (rain gauges), sensors that requires the time counting (sunshine duration, leaf wetness,…), on/off signal (free-contacts); **1 diagnostic input** for battery monitor
Power supply	10…14.4Vdc (typical 12Vdc); On-board battery charger, input from photovoltaic panel, with battery monitoring (deactivation of the load <10,5Vdc, restart >12Vdc) or power supplier 220Vac/12Vdc
Average autonomy of a weather station with 7 measures	• **>15days**: with 12Vdc/7Ah battery, 20W photov. panel, storage: 5' transmission: 60' • **>30days**: with 12Vdc/18Ah battery, 30W photov. panel, storage: 5' transmission: 60'
Transmission of elaborated data	Wireless via **GSM/GPRS** on FTP area wired via **RS232/LAN** cable with PC free software for data download
Transmission of istantaneous data	Option: sensor signals duplication on a interface with **RS485 MODBUS RTU** slave / **TCP/IP** output
Alarm transmission	via e-mail using MeteoGraph web (with GPRS data transmission)
Programming	On site: setting of text file in the SD Card memory
Settable parameters	• Date and time with NTP synchronization (network time protocol) • Anemometer and rain gauge constants • Storage rate (5, 10, 15, 30 or 60'); • Transmission rate (5, 10, 15, 30 or 60');
Elaborations	Min, max (gust), arithmetic average, standard deviation, turbulence; trigonometric average; sum; diagnostic measure for battery voltage. Calculable measurements (if the weather sensors that allow the calculation are present): Evapotranspiration Et0, TD Dew point temperature, TWB wet bulb temperature
Data storage	Data backup of 500 days with circular storage
Conformity	Annex 8 – WMO (World Meteorological Organization)
Working temperature	-30…+70°C
IP65 Enclosure (basic version)	Plastic material Dim.(LxHxP): 250x350x160mm, key closure and universal brackets for mounting on the pole.

mMET3

Datalogger mounting in the IP65 container

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RADIOMETRIC SENSORS **Model**	**PIRSC – Photovoltaic effect pyranometer for global solar irradiance or direct normal irradiance (DNI) on photovoltaic panel**
Measuring range	0…2000 W/m²
Transducer	Silicon cell
Spectral Range	4…1100nm
Accuracy (typ.)	±3.5%
Typ. Output	4...20mA
Calibration	With ISO9060 First Class pyranometer

Models	**PIR2S / PIR01 / PIR02 – Thermopile pyranometers (global solar irradiance)**
Measuring range	0…2000 W/m²
Transducer	Thermopile
Spectral Range	PIR01 and PIR02: 300…2800nm; PIR2S: 283…2800nm
ISO9060 accuracy classes	PIR2S: Secondary standard (high quality) PIR01: First Class (good quality) PIR02: Second class (moderate quality)
Typ. Output	4...20mA
Available certifications	ISO9001 in compliance with ISO9847 norm

METEOROLOGICAL SENSORS **Models**	**mSTA – Air temperature sensor** **STC – Contact temperature sensor**
Air Temperature - Range	-40…+60 °C (air)
Transducer	Pt100 with screen protection
Accuracy	±0.2°C
Contact temperature - Range	-50…+100 °C
Transducer	Pt100 with stick tape for photovoltaic panel
Accuracy	±0.2°C
Common characteristics	
Power supply	+9…+24 Vdc
Typical Electrical output	Vers. –V: 0…5Vdc or –I: 4…20mA

Model	**mWS1 – Wind speed sensor**
Range of measurement	0…50 m/s (typical) gusts >70m/s
Transducer	Magnetic with sine signal not AC powered
Mechanical rotation	Over high-performance bearings
Typical Electrical output	Vers. –N: sine wave AC (frequency max 200 Hz)
Instrumental constant	4.3 Hz/m/s (typical)
Accuracy	± 0.02 m/s

Models	**mWD1 – Wind direction sensors**
Range	0…359°
Transducer	Linear Potentiometer with continuous 360°
Rotation	High performance bearings
Anti-icing heater	12Vdc/1W (only for WD2 model)
Accuracy	< ±2°

Model	**WLS – Leaf wetness sensor**
Measuring range	0…100% of leaf wetness and wetness duration (s)
Transducer	Capacitive
Operative Temperature	-30…+60°C

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Model	RHTT – Soil moisture (temperature and water content)
Range	RH: 0…60% VWC (Soil volumetric water content) T: -40…+60°C
Transducer	Capacitive (RH) and thermo-resistance NTC (T)
Outputs	n.2 0…5Vdc outputs (other on request)
Accuracy	RH: ± 3% VWC between 0 and 50VWC (standard mineral soil, EC <5 mS/cm) T: ±0.5°C (long-term stability: 0.1°C/year)

Model	RG200 – Rain gauge (available with anti-icing heater)
Range	infinite
Orifice area	200cm^2 (option: 400 cm^2)
Transducer	Double contact (n.o.) tilting bucket
Accuracy	Class B UNI 11452:2012 (class A connected to the Geoves' datalogger)
Resolution	0.2 mm/commutation (or 0.1mm 400cm^2 version)
Conformity	WMO

Model	mPA – Micro Barometer
Range (typical)	800…1100 hPa (on request 600…1100 hPa for sites over 1000m above s.l.)
Transducer	Piezoresistive
Accuracy	<±0.6hPa @ 25°C
Long-term stability	±0.01hPa / year

*Other meteorological sensors are available on request

APPLICATION EXAMPLES WITH MicroAGROVOLT STATIONS

PF2-40 – Light pole h=2m with screw tip mounting (without civil works)

PL3-TREP – Light telescopic pole hmax=4m with tripod, screw tip base and ground stakes mounting

Meteorological sensors directly applied on the solar tracker

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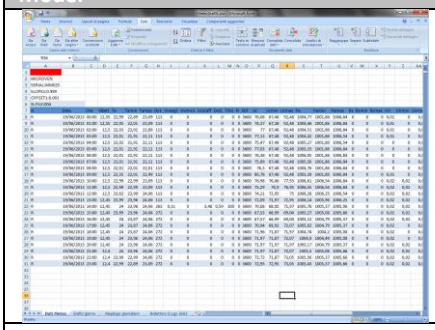
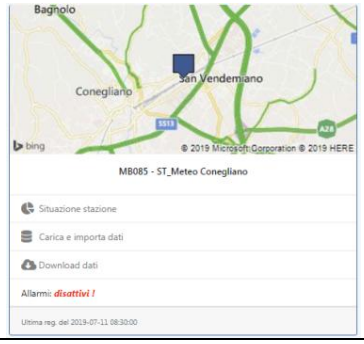
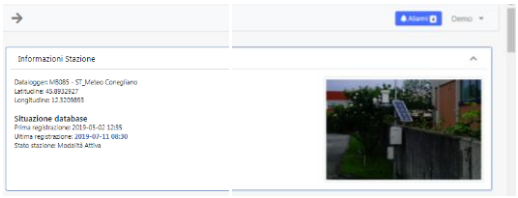
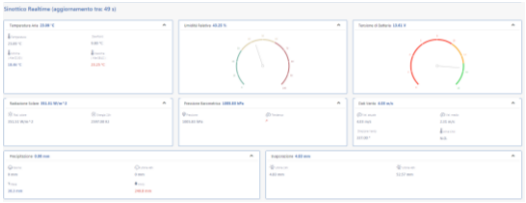
Geodesk&Meteograph – Setup software for Geoves datalogger and web service for data management

SOFTWARE **Model**	**Geodesk & MeteoGraph**
	**Geodesk** is a basic service software, free supplied with all Geoves datalogger, that can import data recorded (on SD card or sent via GPRS or transmitted by cable from the datalogger) and generate a single data file in Excel format. In this way it's possible to create data aggregation of desired period (eg. Monthly) and then derive the tabular and graphical reports. Besides Geodesk creates the setup configuration for the functioning of Butterfly, Micro3 and LPDL Geoves dataloggers
	**MeteoGraph** is a web application for the numerical and graphic display of data transmitted via GPRS on FTP area from environmental monitoring stations with Geoves datalogger. The software relies on an FTP Geoves area where data is sent autonomously by the control units at fixed times and are available in **standard text format** with fields separated by commas (**CSV format**). The data is therefore **always usable** without the need to use proprietary communication protocols or specific programs for data decoding; furthermore, the software **does not require any installation,** all you need is a simple internet access with a common browser, a username and password must be entered to access to the dedicated web page and display the measurements from a PC, tablet or smartphone. The data in text format are processed by MeteoGraph to get on the web page both the measurement in numeric format (eg average minimum maximum trend, etc.) and in graphic format that can be downloaded in jpg bitmap format.
	**Station dashboard** The available functions are: • *Station situation*: access to the graphic processing page and to the station's synoptic • *Load and import data*: the data saved on the datalogger SD card are imported, or on a PC folder (or other support) • *Data download*: data are downloaded in text format with fields separated by commas for simple backups or subsequent processing with other applications (eg Excel, Access, external databases or other commercially available software) • *Alarms*: access to the station alarm management menu (optional on request)

	**Station situation - *Station information***
	The parameters displayed are:
	• Station unique identifier (ID)
	• Name of the station
	• Geographic coordinates (Latitude and Longitude)
	• Data base status:
	  ○ Date and time of Start data storage
	  ○ Date and time Last data storage
	  ○ Operation status of the station
	• Photos of the station

	**Real-time synoptic of the station** The synoptic is a very useful tool for assessing the situation of the latest measurements taken by the monitoring station and assessing the meteorological or environmental situation of the site. For each measurement it is possible to associate one or more dedicated processes. For example, for the temperature it is possible to indicate the minimum and maximum value and the time in which it occurred in addition to other calculated measures such as the dew point.

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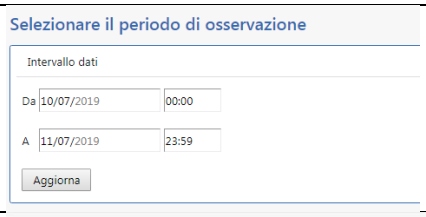
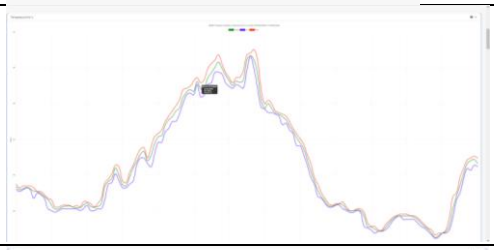
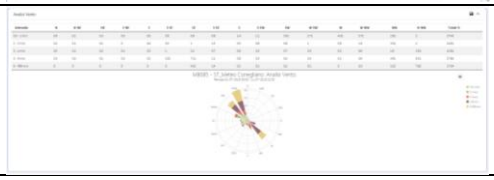
The synoptic also shows:
- calculated measures
- Diagnostic data (eg battery voltage)
- Significant data for the interpretation of the measure (eg barometric tendency, wind chill, monthly precipitation, etc.)



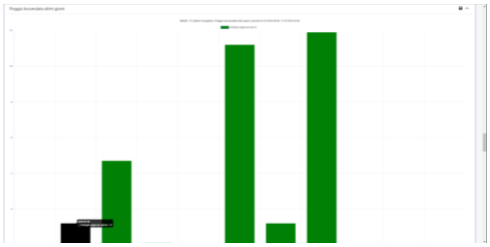
Observation period
It is possible to select the observation period in which to carry out all the elaborations that are displayed by MeteoGraph



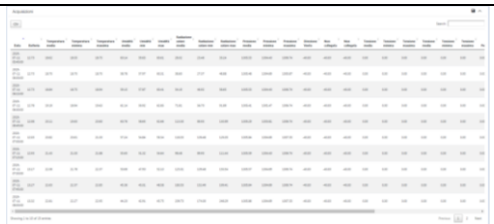
Graphic elaborations
- **Linear multi-line** for measurements where the arithmetic average is applied (eg temperature, humidity, pressure, etc.) with representation of the minimum and maximum value



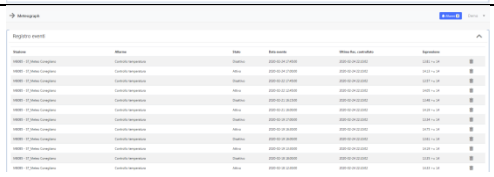
Graphic elaborations
- **Wind-rose** for the anemometer measurements



Graphic elaborations for precipitation
- Graph with hourly summation
- Monthly or annual precipitation histogram
- Other graphs are available on request or can be customized with simple filters



Tabular elaborations
Daily data table can be downloaded both in text and in .png image format



Alarm management
To manage alarms, the software allows you to set upward (> value) or downward (<value) intervention thresholds, after which alert emails are sent to the personnel in charge.
The alarms are then represented on the screen with adequate effects and colors to attract the attention of the operator

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O-Guard – DSS (Decisional Support System) Web service with models for crop monitoring

Modello	O-Guard – Agro-meteorological platform for crops management

Web application: geographic map with meteorological stations network

Forecasting model for fungal diseases and catch of phytophagous insects

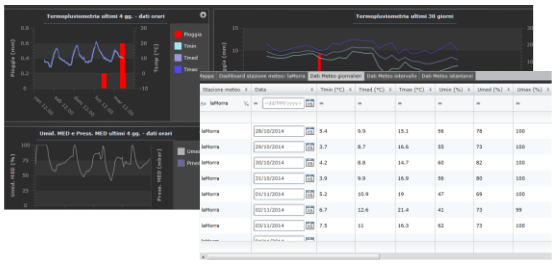
O-Guard is an advanced digital ecosystem, in which technologies and people are connected to each other, through a technological platform that guarantees the processing and distribution of data. The system is accessed from a personal computer, or through mobile devices such as smartphones and tablets. In both cases, Internet connectivity is required to access the system. The web service for PC has a GIS (Geographic Information System) module that allows you to use cartographic sources and view data directly from the map.

It allows to use in an organized way, the measurements of sensors coming from electronic stations installed in the field, the monitoring data of agricultural crops and phytosanitary treatments; it also guarantees real-time updating through a notification system of dispatches and alerts distributed automatically by the system.

The system is particularly suitable for bodies and organizations that provide technical assistance services in the agricultural sector and that need an ICT solution for managing information in conditions of mobility. Typically, organizations that have their own technical staff in the area that need to receive an updated descriptive framework, from an agronomic and agro-meteorological point of view, can benefit from this type of solution during their activity in the field at farms.

Two different applications can be used to ensure the accessibility and usability of agronomic information:

1. **DESKTOP APPLICATION** (In this web platform large amounts of data are accessed from a PC).
2. **MOBILE APPLICATION** (summary data is organized for quick access from a mobile device, eg tablet or smartphone).



Meteo-climatic data elaboration

Main functions of the APPLICATION

Field technicians can use the APPs installed on tablets and smartphones to carry out various activities:

- Annotation and consultation of information relating to the general state of the points monitored from an agrometeorological point of view
- Continuous updating while traveling by car thanks to the "navigation" mode,
- Input from the field of agronomic and cultural data (phenological measurements, climatic damage on the plant, pathogenic organisms, calendar of phytosanitary treatments and irrigation).
- Evaluation of bioclimatic indices and outputs of phytopathological models.

The information provided by the meteorological monitoring system can be used for any crop, herbaceous and arboreal, annual and multi-year, because it provides bioclimatic indices and raw data essential for understanding the seasonal trend and the relationship between plant and environment.

As regards forecasting models, the computerization of phyto-pathological modeling is underway based on the scientific publications available.

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The models already made or under development are indicated below:

	INSECTS	PERONOSPORA	OIDIUM	DIABROTICA	BRUSONE	SCAB	BACTERICAL FIRE	FUSARIUM
CORN	x			x				x
RICE					x	x	x	x
WHEAT AND BARLEY	x							x
BEAN	x							
POTATO	x	x						
TOMATO	x	x						
LIVES	x	x	x					
MELON	x	x	x					
WATERMELON	x	x	x					
ZUCCHINI	x	x	x					
OLIVE	x							
HAZELNUT	x							
HOWEVER	x					x	x	
APPLE TREE			x			x	x	
APRICOT						x	x	
PRUNO						x	x	
KIWI	x							
PEACH	x		x					

Summary of the main strengths

- Accessibility to multi-channel information
- Accessibility in conditions of mobility
- Absence of investments charged to the customer
- System scalability
- Possibility of integrating phyto-pathological mathematical models
- Upload data directly from the field
- Possibility of using GIS tools
- Automatic alert when pre-set thresholds are exceeded

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