Meteotracker Data Services And Visualisation Tools

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1. Introduction

MeteoTracker is a comprehensive hardware and software solution for ultra-high resolution **mobile** weather measurements, based on the ***vehicle as a sensor*** paradigm, typically deploying an existing network of service vehicles (public transportation, delivery services, road maintenance, etc…) as the mobile weather network. Other notable use cases include citizen science campaigns, Road Weather Information Systems applications, sky areas weather monitoring and personal usage.

The massive **high-quality data flow** generated by the MeteoTracker system can play an important role in every context where the characterization of the **microclimate at metre-scale** is needed. Also, it can represent an important asset as a training dataset for current or future **Machine Learning/AI** modeling at hyper-local scales. Real-time maps in urban areas can also be made available, including ad hoc alerts when discomfort heat indexes exceed predefined threshold.

The measuring device (MeteoTracker X device) is a **patented, compact multi-sensor device** (US, EU and JP patent) that gets installed externally to the vehicle by its secure magnetic base. Its measurement compartment is fully exposed to ventilation and, thanks to the carefully engineered design, allows for **very fast measurements**, able to accurately detect the sharpest temperature variations.

By its **BLE connectivity**, it gets connected to a small modem inside the cabin (or the user's smartphone according to the solution adopted) that geo-tags and real-time sends the data to the server.

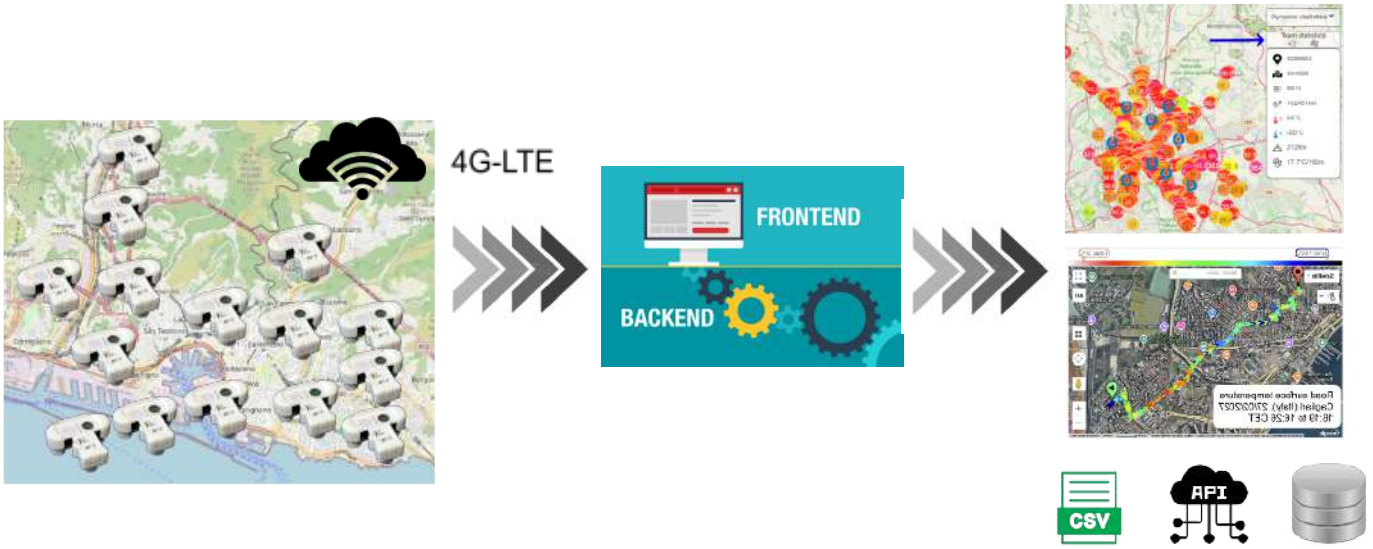
A **software infrastructure operates in the background**, providing tools for data visualisation and storage and a suite of **data services** aimed at extracting the maximum value from the data collected by the MeteoTracker mobile weather network.

Three main tools for data visualization and processing are available:

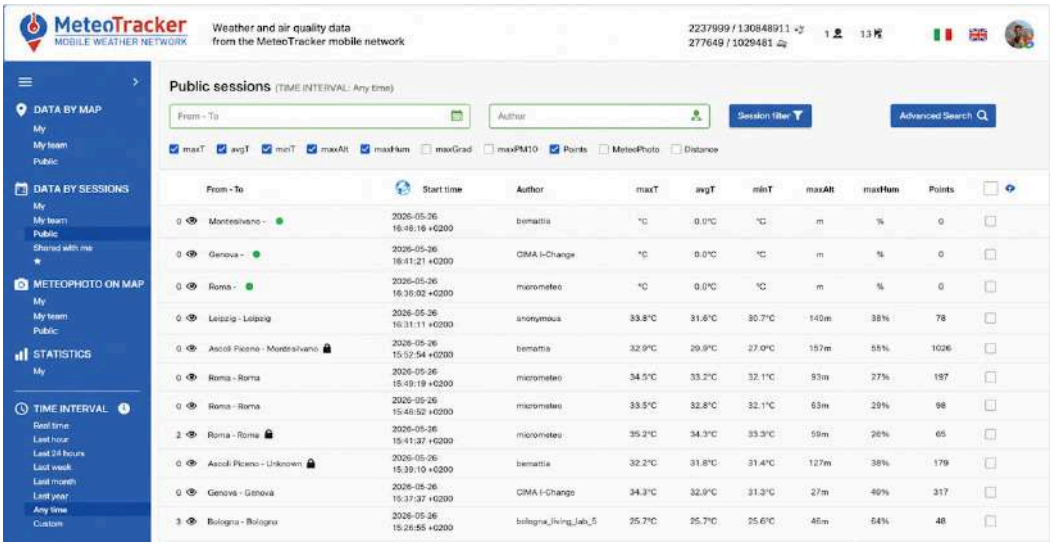
- MeteoTracker dashboard
- MyTeam suite
- APIs

This document is a synthetic description of features and functionalities of the above tools.

2. Architecture



3. MeteoTracker dashboard



The MeteoTracker Dashboard (app.meteotracker.com) is a web-based environmental data visualization and analysis platform designed to manage, explore, and share weather,

infrared and air-quality measurements collected by the MeteoTracker mobile sensor network. It provides real-time and archived session visualization through interactive maps, synchronized graphs, statistics panels, MeteoPhoto integration, CSV export, and advanced analysis tools such as vertical profiles, Skew-T diagrams, and Virtual Fixed Stations. The platform supports multi-sensor environmental monitoring, live session sharing, telemetry supervision, and integration with third-party systems via APIs.

The MeteoTracker database is structured around **weatherpoints** and **measurement sessions**.

A weatherpoint represents the fundamental data entity of the platform and consists of a set of environmental variables measured at a specific georeferenced location.

Measurement sessions are collections of sequential weatherpoints acquired during a monitoring activity, typically representing a route or trip defined by a starting location and a closing location. Each session therefore groups all georeferenced environmental measurements collected during a specific acquisition activity into a single structured dataset.

Sessions are categorized by visibility and ownership (e.g. *My Sessions*, *Team Sessions*, *Public Sessions*, and *Shared Sessions*) and can be accessed through both map-based and tabular interfaces.

The dashboard provides a multi-layer navigation system composed of specific sections such as **Data by Map**, **Data by Sessions**, **MeteoPhoto on Map**, and **Statistics**. Within the *Public Sessions* view, users can browse datasets using temporal filters, author filters, session-type filters, and advanced search functions.

Each session entry contains metadata and aggregated indicators including:

- geographic route,
- session start timestamp,
- author and originating device,
- statistics
- number of acquired measurement points,
- multimedia availability (MeteoPhoto),
- session visibility and sharing status.

Data visualization is supported through map-synchronized analytical graphs, statistical summaries and configurable parameter overlays (e.g. average temperature, minimum/maximum values, humidity, altitude, PM10 concentration, vertical thermal gradients and distance metrics). The platform also supports real-time and historical analysis through selectable temporal intervals such as *real time*, *last hour*, *last 24 hours*, *last week*, *last month and custom intervals*.

4. MyMobileWeatherNetwork and MyTeam suites

The **MyMobileWeatherNetwork (MMWN)** and **MyTeam** suites are dedicated platforms designed for the centralized management of MeteoTracker data and users within collaborative environmental monitoring networks.

- **MyMobileWeatherNetwork (MMWN)** is specifically developed for managing fleets of vehicles equipped with MeteoTracker Standalone devices. In addition to data visualization and analysis functions, it includes telemetry and diagnostic tools for monitoring device status, configuration, connectivity, and sensor operation, making it particularly suitable for professional fleet supervision and maintenance.
- **MyTeam** is designed for citizen-science and collaborative monitoring projects, where data collected by multiple users must be centrally managed within a hierarchical privacy and access-control structure.

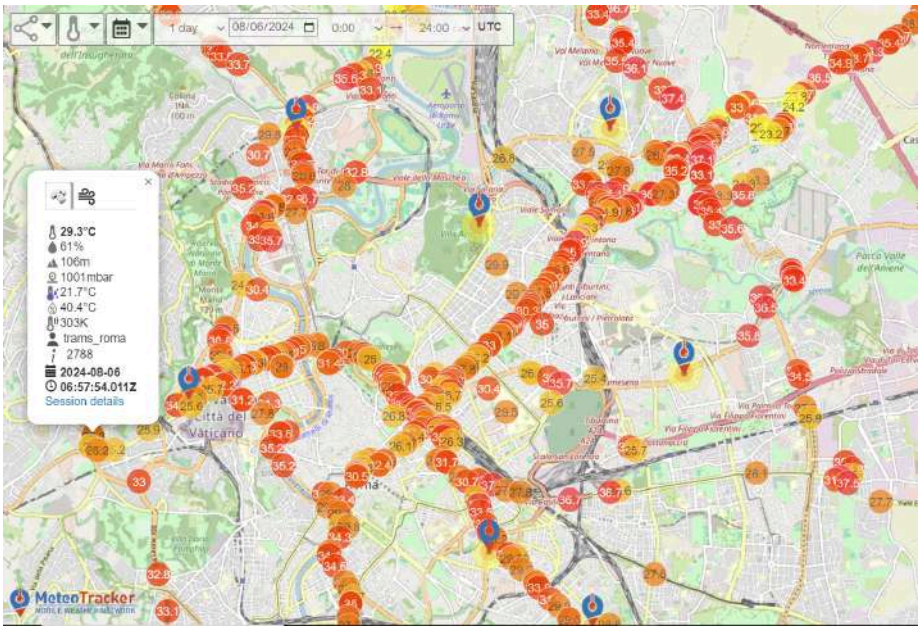
Both suites provide advanced yet intuitive tools for environmental data analysis, visualization, sharing, and export. They also include a flexible geo-fencing functionality called **Virtual Fixed Station (VFS)**, which enables the transformation of MeteoTracker's inherently spatial measurements into fixed-location time series suitable for temporal analysis and long-term monitoring.

A detailed description is provided in the following sections.

4.1. Interactive map

The MeteoTracker interactive map is a customized map included in the MyTeamsuite, where measurements collected by the MeteoTracker devices belonging to a **team** are real-time visualized. Also, historical data can be retrieved, by selecting the date and time interval of interest.
Each weatherpoint is shown as a circle with the measured value. The parameter to be shown (temperature, humidity, etc…) is selected by a drop-down menù. Clicking on a circle, **all the data collected** in that geographical point are displayed.

Date and time interval can be chosen by a dedicated **calendar** The time resolution is as fine as 1-hour time frame.



4.2. Virtual Fixed Station

The **Virtual Fixed Station** (VFS) is a MeteoTracker **geo-fencing** functionality where one or more geographical points of interest are selected by the user; and where **one or more radius** can be set around that point. All the MeteoTracker measurements collected within those radius are **captured and saved as a time-series sequence** and can be processed through dedicated APIs, CSV export and graphs. The typical applications of a VFS includes:

- **comparison** between fixed weather station and MeteoTracker data;
- **evaluation of the impact of peculiar orographic/topographic or other territorial features** (green area, water body, urban density, etc…) on the microclimate of a given area (e.g.: a user can set a radius of 30 m and a radius of 250 m; within the 250 m radius the MeteoTracker measurements collected in a wide green area are captured, influencing the average air temperature values; within the 30 m radius no green areas are included);
- **space to time domain transformation** for data processing purposes

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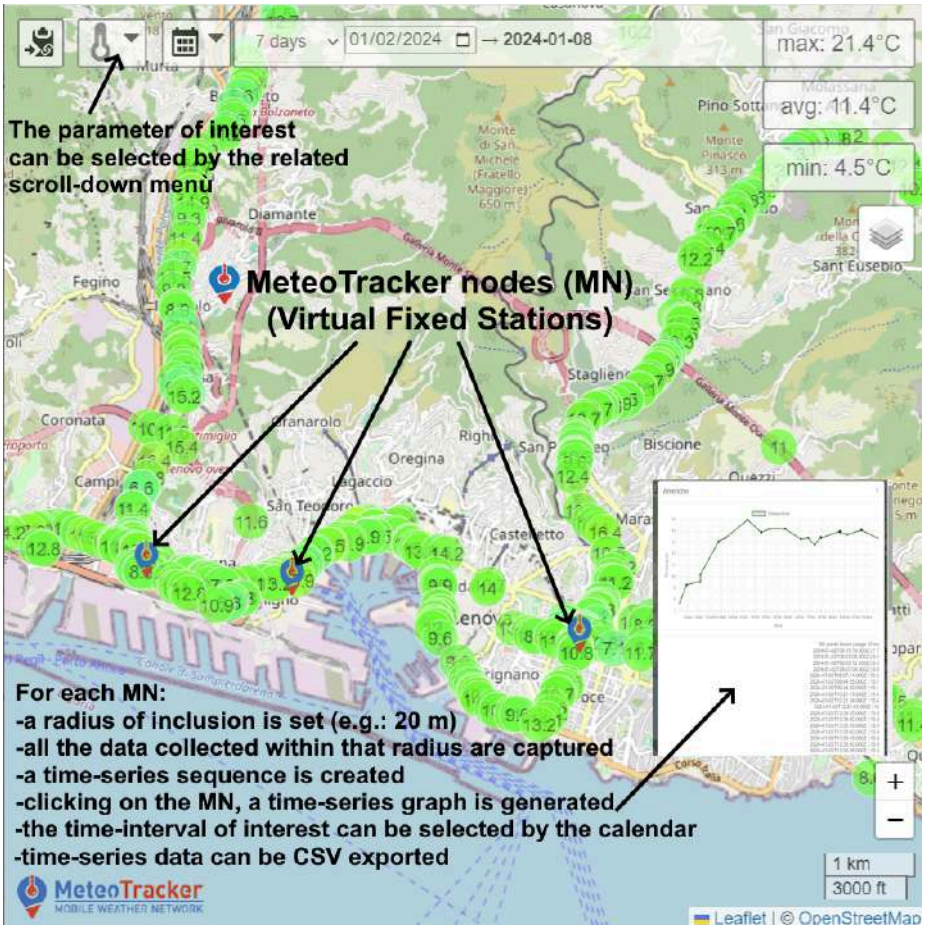
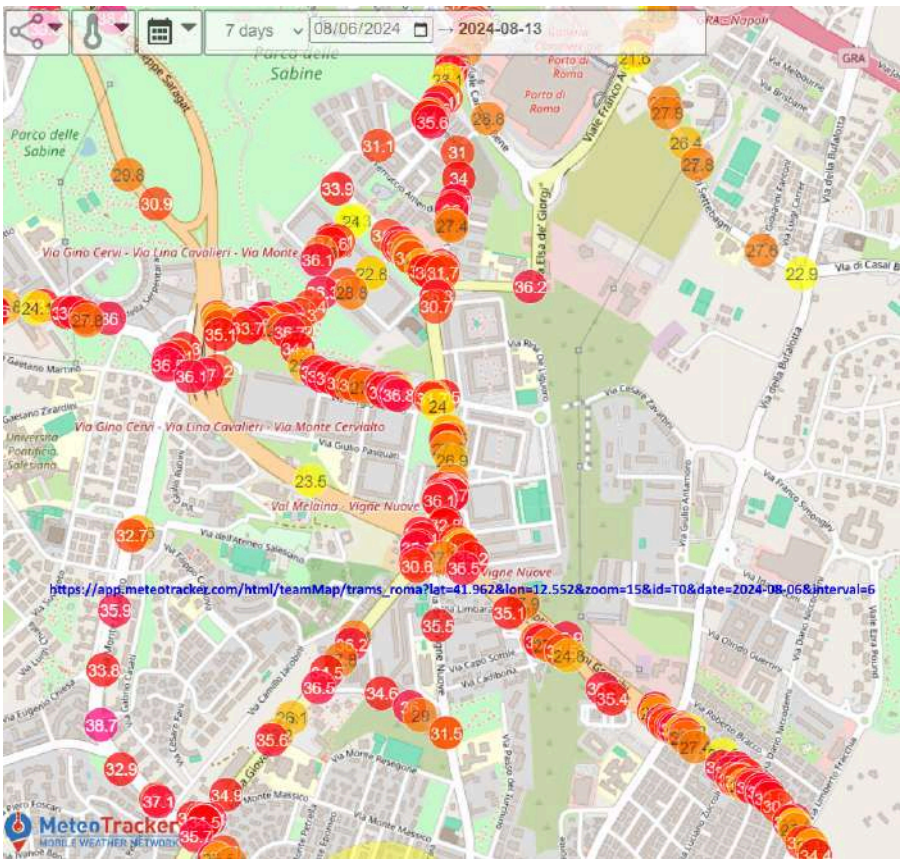


4.3. Smart URL

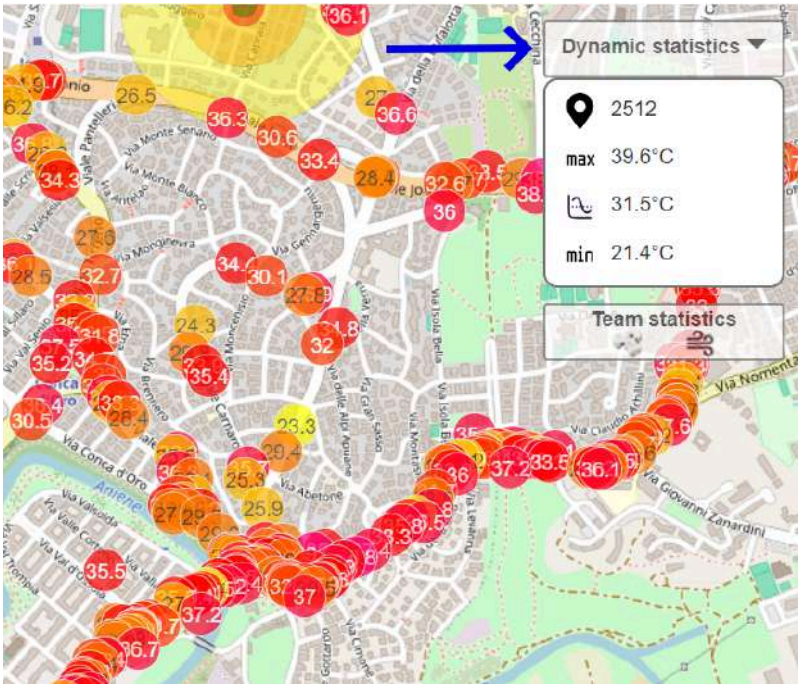
"Smart URL" is a feature that generates a **URL** referred to the selected (by the user) geographic area, parameter, date and time-frame in the interactive map. Here is an example from the **Roma Heat Mapping** project:

https://app.meteotracker.com/html/teamMap/trams_roma?lat=41.920&lon=12.490&zoom=14&id=T0&date=2024-08-06&interval=6



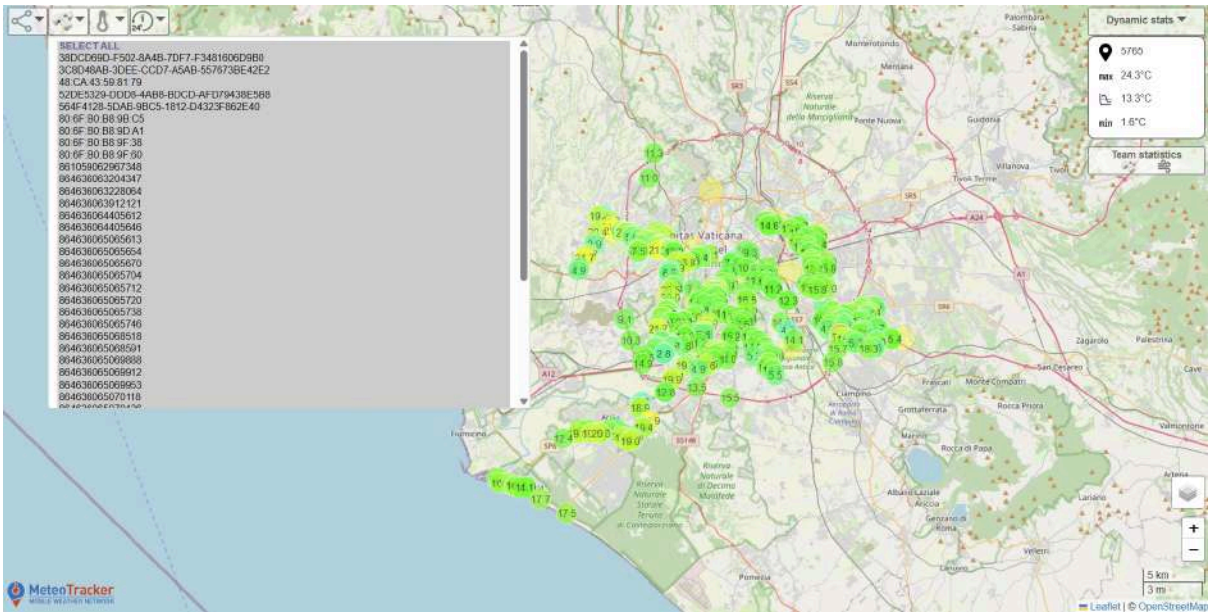
4.4. Dynamic statistics

“Dynamic statistics” is tool that extracts statistics values related to the data collected in the **geographical area** framed in the map.



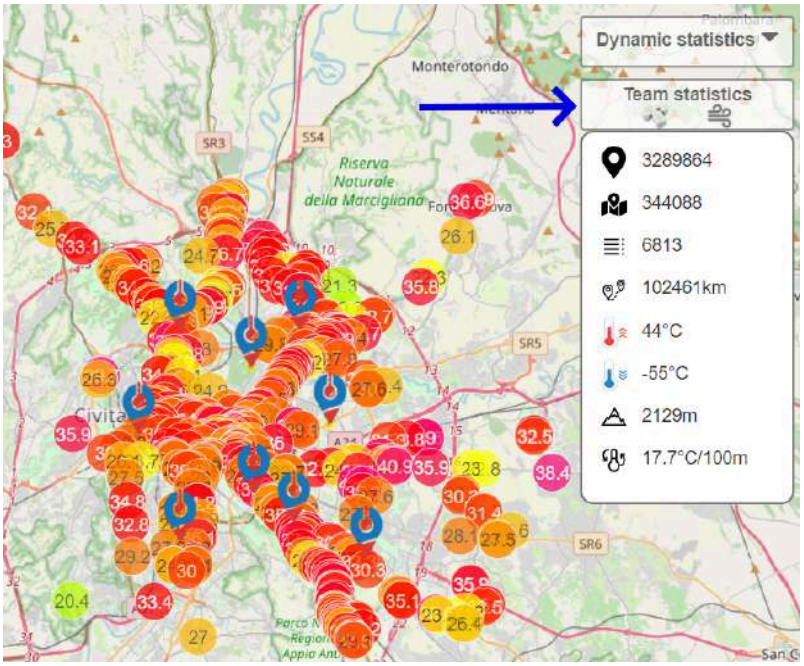
4.5. Filter by device

In the upper-left menù, the “filter by device” feature is available. Selecting the designated device, only the related data are shown in the map. Multiple selections are allowed.



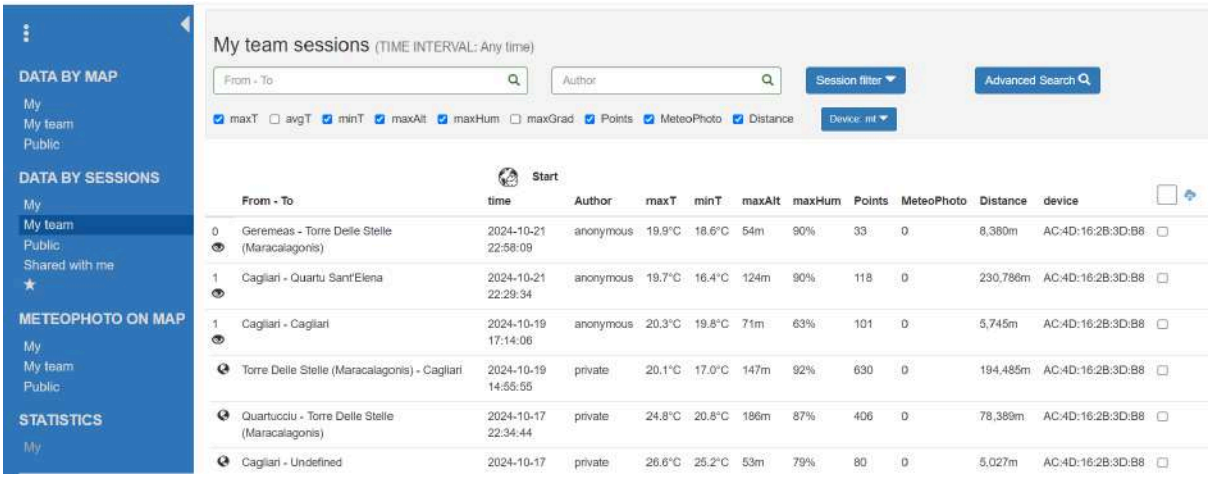
4.6. Team statistics

“Team statistics” is a feature that returns statistics values related to **all the database** generated by a team



4.7. Team archive

“MyTeam” is a page on the MeteoTracker dashboard where only the **data collected by the team’s members** are presented and made available for in depth analysis and extraction, including batch CSV export. It is available on the MeteoTracker+ App (Android) as well.



4.8. CSV data export

"MyTeam" encompasses different CSV data export functionalities:

- **batch download**: multiple selection of the sessions of interest (from the "My Team" list) allows for "one-click" downloading of the CSV file of each session that includes all the measured parameters (geo and time-tagged);
- **selection of the parameters to be downloaded**: opening the session of interest, the CSV download button placed above the graphs column allow for the CSV download of the parameters plotted in the graphs;
- **automatic file naming with all the session IDs**: the CSV files are automatically named including all the sessione ID: departure and arrival location; author; time and duration; MeteoTracker device ID (BT mac address).

4.9. Telemetry (MMWN only)

A dedicated telemetry panel is available for monitoring the operational status of each MeteoTracker device, including:

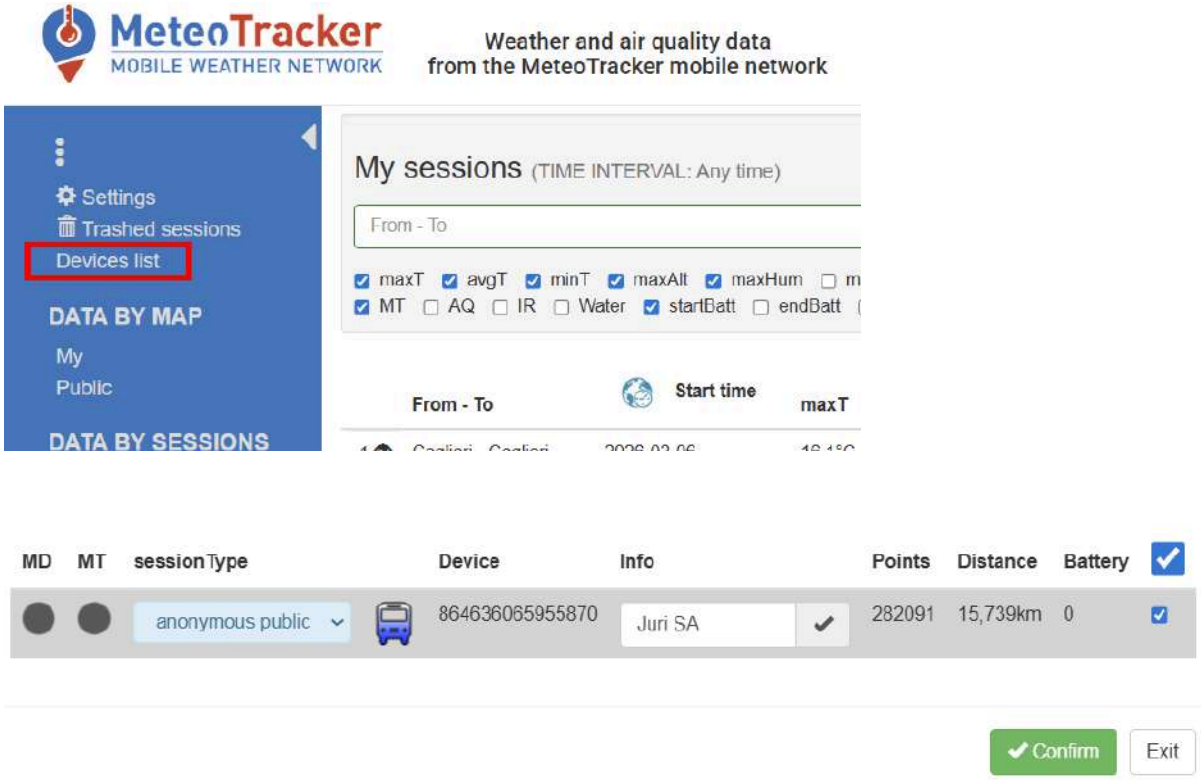
- Modem connectivity status
- MeteoTracker data transmission flow
- Device battery level

Through the same interface, users can also:

- Configure the privacy level associated with data collected by each device (e.g., public anonymous, public signed, private)
- Assign custom tags to individual devices, such as the identification code or vehicle number of the bus, car, or platform where the MeteoTracker unit is installed

In addition, the platform displays operational and statistical information for each device, including:

- Modem IMEI identifier
- Total number of weatherpoints collected
- Distance traveled (kilometers) during monitoring activities



5. API

MeteoTracker offers a **wide range of APIs** for real-time and historical data processing within **third-party platforms**. Here is the dedicated webpage, with details and code: https://app.meteotracker.com/api-docs/

The main entities managed by the MeteoTracker APIs are ***weatherpoints*** and ***sessions***

5.1. Weatherpoints

Data collected by MeteoTracker mobile sensors are available in the form of **WeatherPoint.** A WeatherPoint currently contains 9 weather parameters plus speed, latitude, longitude and time associated with that measurement. They include **air quality parameters and ground surface temperature** if the measuring devices (MT-Air Quality and MT-Infrared devices) are used.
WeatherPoint data may be filtered **by Area** (data included in a selected geographic area), by **Session** and by **Team** (data collected by all the sensors associated to a team). Each data request must include a time interval and the response data is formatted as **JSON**. Team-filtered and Area-filtered WeatherPoints are available in **HTML** format, too.
Below are the lists of weather and air quality parameters included in a WeatherPoint.

Weather parameters

- ***T0*** air temperature [°C]
- ***H*** relative humidity [%]
- ***a*** altitude [m]
- ***P*** pressure [mbar]
- ***td*** dew point [°C]
- ***tp*** potential temperature [K]
- ***HDX*** humidex [°C]
- ***i*** vertical temperature gradient [°C/100m]
- ***s*** speed [km/h]
- ***L*** solar radiation index
- ***bt*** bluetooth RSSI [dBm]

Air Quality parameters

- ***CO2*** carbon dioxide [ppm]

- ***m1*** mass concentration PM1.0 [µg/m3]
- ***m2*** mass concentration PM2.5 [µg/m3]
- ***m4*** mass concentration PM4.0 [µg/m3]
- ***m10*** mass concentration PM10 [µg/m3]
- ***n0*** number concentration PM0.5 [#/cm3]
- ***n1*** number concentration PM1.0 [#/cm3]
- ***n2*** number concentration PM2.5 [#/cm3]
- ***n4*** number concentration PM4.0 [#/cm3]
- ***n10*** number concentration PM10 [#/cm3]
- ***tps*** typical part size [µm]
- ***AQI*** Full Air Quality index (PM2.5, CO, SO2, O3 and NO2 based)
- ***EAQ*** EPA Air Quality index (O3 and NO2 based)
- ***FAQ*** Fast Air Quality index
- ***O3*** ozone [ppb]

Ground surface temperature

- Tir

5.2. Session data

A set of data related to a session are made available through APIs.

A **Session** represents the dataset collected by a user/vehicle during a trip. It includes information related to the trip, such as departure and arrival locations, the number of WeatherPoints collected, the maximum and minimum values measured, the total distance traveled and others, as listed below.

A **MeteoPhoto** is a feature of the MeteoTracker App that enables the acquisition of pictures where **weather data**, location, date and altitude are tagged in the header or footer of the picture, thus allowing a visual documentation of the **environmental conditions and orography** where the WeatherPoint is collected. MeteoPhotos are shown in the dashboard and on the interactive map, identified by an icon positioned in the exact location where they have been taken.

MeteoPhotos are grouped by Area or Session, but a single MeteoPhoto request is available as well.

Below is the list of parameters related to a MeteoTracker session made available via API.

- ***fromTo*** place of departure and arrival
- ***by*** user field (only for signed public Sessions)
- ***startTime*** session start time [UTC Date o timestamp]
- ***endTime*** session end time [UTC Date o timestamp]
- ***nPoints*** session total points number
- ***nPhotos*** session total MeteoPhotos number
- ***myMap*** my (or my team's) meteotracker data
- ***allMap*** meteotracker public data
- ***myPhoto*** my (or my team's) meteotracker photos
- ***allPhoto*** meteotracker public photos

The complete API list (https://app.meteotracker.com/api-docs/) is shown below.

For more information and purchasing:

www.meteotracker.com

info@meteotracker.com

https://www.linkedin.com/company/meteotracker